S. A. E. JOURNAL

Vol. XXII May, 1928 No. 5

Activities Focus on Quebec

Six Hundred Reservations Received—President Beaumont To Head Institution of Automobile Engineers Delegation

ALTHOUGH the Meetings Committee, in choosing the place for the 1928 Summer Meeting, fully appreciated the advantages of Quebec for the occasion, it did not expect that, within one week after the reservation blanks were mailed to the members, one-half of the available accommodations at the Chateau would be taken. At the time of going to press, more than 600 reservations have been received.

Chateau Frontenac has one advantage over hotels at which other Summer Meetings have been held, which should be appreciated by members staying over Saturday night: almost every room has a private or adjoining bath.

I.A.E. To Send Delegation

With a great deal of pleasure the Meetings Committee announces that Major E. G. E. Beaumont, president of the Institution of Automobile Engineers, will head a delegation of members of the Institution to the Summer Meeting. This will be the first official delegation to be sent to an S.A.E. meeting since 1913.

Among the I.A.E. members are H. L. F. Orcutt, managing director of the Gear Grinding Co., Ltd.; C. R. Charles, director of Dennis Bros., Ltd.; F. W. Smith, director of the Enfield Cycle Co., Ltd.; H. S. Green, of the Standard Motor Co., Ltd.; Thomas Clarkson, consulting steam engineer; T. H. Thorpe, consulting engineer, and W. P. Meeson, works manager, and G. H. Savage, of the Hillman Motor Car Co., Ltd.

The Sports Program

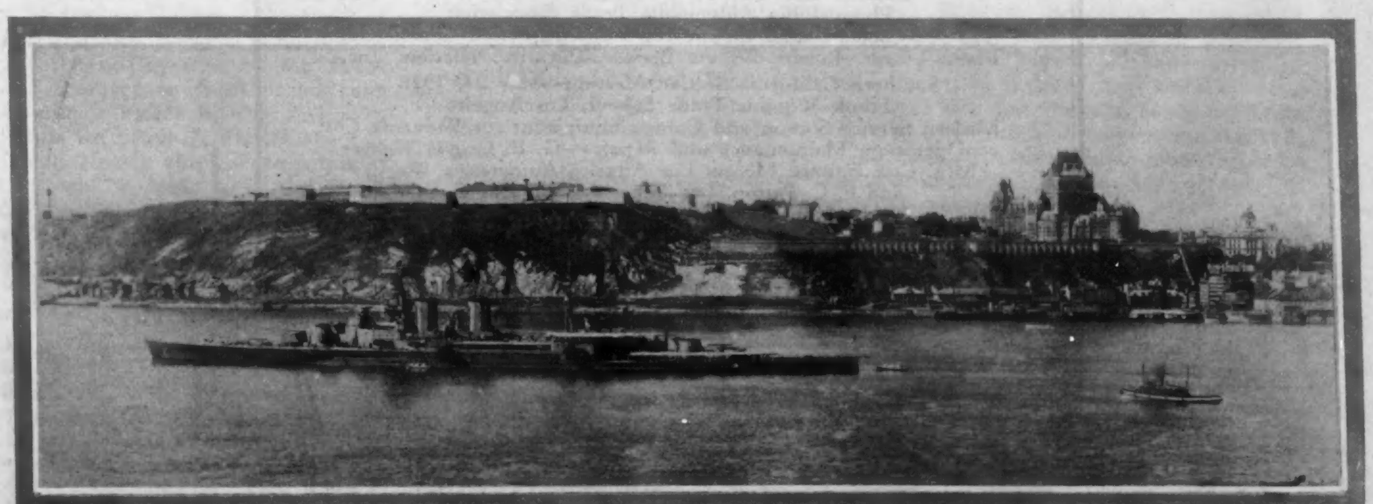
The Quebec Golf Club, one of the oldest courses in North America, will be available to members entering the Men's Golf Tournament at Quebec. The 16 lowest scores turned in for the qualifying round of 18 holes will determine the make-up of the championship flight. The first flight will be made up of the two representatives of each Section who have the lowest and next lowest scores. Additional flights will be made up in the same way so that there will be inter-Section competition as well as individual competition. In addition to the individual prizes, an inter-Section golf championship cup will be awarded to the Section winning the greatest number of points.

A driving contest and an obstacle contest are also being arranged. There is also a possibility that a special *approach* tournament will be held, the ball to be played from the top of Montmorency Falls to a *green* marked on the opposite side of the whirlpool at the bottom of the falls. And it might be mentioned that Montmorency Falls is one hundred feet higher than Niagara Falls.

In addition to the regular golf tournament for the ladies, which will be held on the Kent Golf Course, a pitch and put, as well as a flag or tombstone, tournament will be arranged. There will also be a *mixed* foursome event, details of which are to be announced by the Golf Committee at a later date.

The Meetings Committee has arranged for tennis and archery tournaments, also. The tennis courts are within five minutes' walk of the hotel, and the archery tournament will be held, by special permission, in the moat of the citadel, which is within only a few minutes' walk of the Chateau. Here, under almost medieval surroundings, the men as well as the ladies will have an opportunity to show their skill as Robin Hoods. William Tells are barred from the tournament.

It is expected that bridge will be as



S. A. E. Meetings Calendar

Summer Meeting
June 26 to 29, 1928
Chateau Frontenac, Quebec

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Buffalo Section Meeting
Hotel Statler
Outboard Engines—Mr. Johnson, Johnson Motor Co.

Chicago Section Meeting—May 15, 1928
Chicago City Club
F. E. Moskovics

Cleveland Section Meeting—May 14, 1928
Cleveland Hotel
The Instability of the Front End of Automobiles
J. F. Duby, Automotive Shop Equipment Co.
F. F. Chandler, Ross Gear & Tool Co.

S. A. E. Club of Colorado—May 15, 1928
Argonaut Hotel, Denver
Aircraft Engines

Dayton Section Meeting—May 25, 1928
Engineers' Club
Induction Systems and Air-Cleaners—C. S. Kegerreis, Tillotson Carburetor Co.

Detroit Section Meeting—May 7, 1928
Book-Cadillac Hotel
C. F. Kettering

Indiana Section Meeting—May 19, 1928
Purdue University, Lafayette, Ind.
Inspection of Laboratories
Diesel Engines—Prof. A. E. Hershey, University of Illinois

Metropolitan Section Meeting—May 17, 1928
Building Trades Club
Motorcoach Meeting

Milwaukee Section Meeting—May 2, 1928
Milwaukee Athletic Club
Recent Developments in High-Speed and High-Efficiency Engines—F. S. Duesenberg, Duesenberg, Inc.

New England Section Meeting—May 9, 1928
Boston
Electrical Service for Automobiles—D. P. Cartwright, North East Electric Co.

Northern California Section Meeting—May 10, 1928
Engineers' Club, San Francisco
Commercial Bodies

Pennsylvania Section Meeting—May 8, 1928
Philadelphia Automobile Trade Association
The Air-Cooled Radial Engine for Moderate-Priced Commercial Planes—Capt. Robert W. A. Brewer, Pitcairn Aviation, Inc.

Southern California Section Meeting—May 25, 1928
Frank Wiggins Trade School, Los Angeles
Modern Service Station and Garage Equipment for Reducing Cost of Operation, Maintenance and Repairs—G. F. Grove, Weaver Mfg. Co.; Eustace Moore, Los Angeles Automotive Works and F. C. Patton, Los Angeles Motor Bus Co.

Washington Section Meeting—May 25, 1928
Racquet Club
Racing—Wade Morton, Auburn Motor Co

popular as ever, and several sessions are being planned. The Quebec Bridge is world famous.

Special Trains Scheduled

A *very special* Canadian-Pacific timetable, giving the special-train and special-car arrangements, has been sent to all members. Railroad certificates, entitling members to the fare-and-a-half privilege, will be mailed with the next special notice about May 14. Reduced-fare railroad tickets may not be purchased prior to June 22. No ticket validation will be necessary at Quebec. Members should notify their Society representatives promptly regarding accommodations they will need, so that the railroads can requisition sufficient train equipment.

Quebec in June

Attention of the world has been focused on the northern Canadian provinces, and especially Quebec, owing to the flight of the Bremen. The fact that Quebec is still experiencing winter weather explains the Meetings Committee's decision to schedule the Summer Meeting late in June, the latest date possible for the Chateau to be turned over to a convention. The tourist season starts with the Fourth of July, which comes the week following.

June in Quebec corresponds with May in the States and, although the days will be warm, the evenings will be cool; therefore, warm evening wraps should be included in the clothing to be taken. The ladies should also be cautioned to take a pair of low-heeled shoes, as the cobblestones in Quebec are not kind to high-heels.

Sightseeing Trips

Replies to the sports and entertainment questionnaire indicate great interest in the sightseeing trips that will be a special feature of the Summer Meeting. In addition to trips to historic points in the city, special trips will be made to Spencerwood, the residence of former Governor-Generals of Canada and the present residence of the Lieutenant-Governor of the Province of Quebec; to Kent House and Montmorency Falls; to the shrine of Ste. Anne de Beaupré, and to the Isle d'Orleans. Nearly all of these points of interest can be seen from the tower of the Chateau, owing to its commanding view from Cape Diamond.

Saguenay River Trip

The Saguenay Post-Convention Cruise is not an official part of the S.A.E. Meeting, but no doubt many members will avail themselves of the opportunity to take this boat trip, which is one of the most beautiful in the northeastern part of the continent. The steamer Richelieu, of the Canada Steamship Lines, will leave Quebec on Saturday at 7 a.m., returning Sunday, July 1, at 8:30 p.m. Reduced-fare certificates will be good until July 5.

That the Saguenay River trip is well worthwhile will be appreciated from the fact that several of the Atlantic steamship companies are planning special two-week summer cruises from New York City to Quebec and the Saguenay River.

SPECIAL WARNING!

A special committee, on which each Section is represented, has been appointed to arrange for an event to start at 10 p.m. on the first evening of the meeting. Although the details of this event may not be announced at this time, members are urged to come to the meeting prepared to take part in an event which will be the most extraordinary feature of the 1928 Summer Meeting.

A Quebec Sketch Book

No one but an artist can depict the real charm of old Quebec. If you suspect that Quebec has been oversold in an effort to attract tourists, ask the Society to send you a copy of A Quebec Sketch Book. With a subtle and most delicate art, Esther Brann, who is both the author and illustrator, has captured by brush strokes and phrasing the intangible yet unforgettable charm of the quaint old walled town. She tells its story simply and takes the reader around Quebec, through narrow streets, to such places as the Dufferin Terrace, the Citadel, Maison Montcalm, the Plains of Abraham, Isle d'Orleans, Sous-le-Cap Street, Ste. Anne de Beaupré and many other intimate historic places. No matter how well you know Quebec, she shows you something new or something old in a new light. Her exquisite water colors, which are most excellently reproduced, are of even more interest than the story. One dollar should be mailed to cover the cost of the Sketch Book.

Special Souvenirs

Arrangements have been made by the Meetings Committee for special souvenirs for the ladies; it is hoped that these will serve as a reminder of the most interesting Society meeting ever held.

Excellent Technical Program Arranged

Nine technical sessions are to be held during the meeting. These, in the order of their sequence, are General, Chassis, Transmission-Production, Foreign, Engine, Transportation, Body-Design, Transmission and Research. Copies of papers to be presented will be available in preprint form for study prior to the meeting. Members are urged to obtain copies of the preprints so that they can be prepared to take an active part in discussion.

The presence of M. de Lavaud at the Semi-Annual Meeting will more than compensate for his absence from the Annual Meeting last January, as the Meetings Committee has just been informed that he is preparing for the Chassis Session an additional paper that will serve as a basis for discussion of his Annual Meeting paper on Independently Sprung Front Wheels as a Remedy for Shimmy. The new paper will be on the Synchronism of the Front Wheels.

As stated in the April issue of the S.A.E. Journal, M. de Lavaud's paper on his automatic transmission is to be presented at the Transmission Session. Preprinted copies of this paper are expected to be available shortly.

Two papers have been scheduled for the Engine Session, the first by Dr. E. J. Martin and D. F. Caris, of the General Motors Corporation Research Laboratories, on Engine Indicators, and the second by T. J. Lítle, of the Marmon Motor Car Co., on Methods of Obtaining Greater Power from Engines Than Formerly. Dr. Martin's paper describes in detail the design and operation of a new type of engine indicator that has been developed, and is accompanied by indicator charts that make it possible to compare results obtained with various types of indicator now used in engine testing. These charts indicate that the length of tube used in indicators of current type influences the indicator diagram to a marked extent. This joint paper by Dr. Martin and Mr. Caris doubtlessly will be one of the most valuable of the papers presented at the Summer Meeting. It will be available later in preprint form, and all engineers interested in engine design are urged to come to the meeting prepared to discuss the subject.

Prof. E. H. Lockwood, of the Sheffield Scientific School, will present a very timely and interesting paper at the Chassis Session on the subject of automotive brakes and safety. His paper will put forward some constructive criticisms and suggestions that will appeal to automobile manufacturers and users and to the administrators of the motor-vehicle laws.

Three papers will be presented at the Research Session. Donald B. Brooks will discuss the influence of fuel characteristics on acceleration; O. C. Bridgeman will discuss gasoline dew-points and vapor-pressure measurements; and H. H. Allen will report the results of further work on the head-lighting investigation being carried on under the direction of the Joint Steering Committee on Headlighting.

The complete program, which lists 21 technical papers and addresses, will be mailed to the members on May 14.

Chronicle and Comment

ALTHOUGH Chateau Frontenac will have Summer Meeting accommodations for more than 1000 guests, the Meetings Committee, judging by the rate at which reservations are coming in, anticipates that it will be impossible to comply in all respects with reservations received during June and possibly the latter part of May. Members are therefore urged to send their reservations in at the earliest possible date to secure the best accommodations then available.

Automotive Phases of CO Research

THE Research Committee, at its meeting last fall, instructed the Research Department, in view of the general interest in the subject, to prepare for the Automotive Research section of THE JOURNAL an article dealing with certain phases of carbon-monoxide research.

The carbon-monoxide content of the air in streets, garages and tunnels due to automobile exhaust-gas, the physiological effects of such concentrations, and the use of ozone in combating them in garages were the aspects selected as particularly pertinent to the automotive industry. The Research Committee thought it advisable to deal with these topics by summarizing the data appearing in the literature and by consulting organizations that have carried out, or are carrying out, relevant investigations.

The article prepared in accordance with these instructions appears in the Automotive Research section of this issue.

The Sections

APRIL was Section visiting month for officers and members of the staff of the Society. President Wall attended the session of the Governing Committee of the Chicago Section on April 12. F. F. Chandler, former member of the Council, and past-chairman of the Sections Committee, participated in the deliberations of the officers of the Cleveland Section on April 10. V. G. Apple, chairman of the Sections Committee, gave advice when the Dayton Section Committee convened on April 11; John Younger, former vice-chairman of the Sections Committee, and now chairman of the Publication Committee, also conferred with officers of the Section located at the home of the Wrights. The meeting of the Indiana Section on April 12 was attended not only by President Wall, but by two Past-Presidents of the Society, Howard Marmon and T. J. Litle, Jr. F. G. Whittington, member of the Council and chairman of the Chicago Section, presided at the meeting of its committee. The meeting of the Aeronautic Division of the Detroit Section last month was attended by the following members of the office staff of the Society: R. S. Burnett, manager of the Standards Department; A. J. Underwood, Standards Department; C. E. Heywood, manager of the Meetings and Sections Department; and C. F. Clarkson, general manager. Members of the Council who attended this meeting included Second Vice-President H. T. Woolson and Councilor J. W. White. The latter attended also the session of the Governing Committee of the Buffalo Section held on April 19.

During the month Mr. Clarkson visited all of the Sections east of the Mississippi River that he had not already visited this year, and attended sessions of their Governing Committees and conferences of officers. There was good representative attendance at the Governing Committee meetings held in Washington, Cleveland, Dayton, Indianapolis, Chicago, Milwaukee, Buffalo and Boston, there being eight or more present in most cases. Remarkable interest in and attention to the work of the Sections was evinced in all cases. The members in general will be gratified to know how earnestly and faithfully the Section officers study and conduct the work of the basic home-ground activities of the Society. During the conferences, various ambitions and problems of Sections were discussed, including those that have been before the Council recently, relating to size and manner of issuing the TRANSACTIONS, increasing the membership of the Sections, the desirability of entertainment features at Section meetings regularly, the most helpful kinds of activity for Sections not located at automotive manufacturing centers, the desirable size of territory for a given Section, and the best methods for maintaining adequate communication between Section headquarters and the office of the Society. Interest was largely centered of course in the Summer Meeting to be held at Quebec next month. In New England Section territory there is naturally much interest in operation and maintenance affairs. Service managers of long experience associated with leading passenger-car companies are keenly desirous that the Society support all movements looking toward increased satisfaction in the use of automotive apparatus.

From the standpoint of the office of the Society, the trip around the Sections circuit was most satisfactory and pleasant.

Dynamometer Testing of Ordnance Vehicles

ORDNANCE Technical Note No. 9, Dynamometer Testing of Ordnance Vehicles at Aberdeen Proving Ground, by Major A. B. Quinton, Jr., and Capt. John K. Christmas, is interesting from three angles. First, equipment and procedure for field determinations of tractive resistance and drawbar pull and for laboratory tests of engines and transmissions are described in detail. Second, results of tests on tractors, trucks and cross-country cars are set forth. Finally, the effects of certain individual factors on the power output are discussed.

Copies of this technical note are not generally obtainable, nor is the Office of the Chief of Ordnance in a position to answer inquiries on its contents. The Research Department will be glad to lend its copy of the note to members or to give further information concerning it.

An American Merchant Marine

By Otis D. Treiber[1]

THE engineering phase of the American merchant marine is a minor matter that American engineers can solve. What is needed now is a realization that the United States must have a great merchant marine to carry our products in times of peace and war and the enactment by the Congress of merchant-marine legislation favorable enough to encourage private capital to invest in ships for foreign commerce and transoceanic passenger travel. We shall never have a merchant marine until such legislation is passed, but when this is done the Government will doubtless have less expense than it now has trying to keep a few ships in operation and American engineers will benefit by the greater engineering activity in America.

The future merchant marine must be built with Diesel-engine power. What type, no one knows. Perhaps several types will prevail for all time. Nearly every kind is now operating except the ship with light-weight high-speed Diesel-engine electric drive. This type seems to offer great advantages in weight, flexibility, low first cost and ease of operation.

Otis D. Treiber

The question of an American merchant marine has considerable bearing on the continued success of American-built products that are or might be used abroad, particularly in times of international war.

At the beginning of the Civil War, ships of the United States carried the bulk of ocean world-commerce, but that war brought our pride of the seas to a sudden end and, in the years following, England gained supremacy in ocean traffic and made great advances in the building of steamships for freight and passenger service. Ship design and construction were standardized and definite rules made governing the structure of all parts of a ship that affect the strength, safety or life of a vessel at sea. The association of Lloyds was formed in England and fostered these rules. It surveyed and classified vessels, and ship insurance rates were based on the Lloyds rating. All England must have worked together to build up this great business. We Americans could learn from the cooperation in England, the fruit of which is the great British merchant marine.

Germany and the Scandinavian countries contributed a great deal to building ocean traffic, with Germany an important competitor of Great Britain until the outbreak of the World War; but America's proud merchant fleet did not return. Enough battleships were built each year for the United States Navy to keep a skeleton crew of engineers and mechanics occupied from year to year in five or six shipyards in America, and a few other yards built coasting vessels or lake carriers, but very few ocean carriers were built in America from the Civil War to the World War and no transoceanic passenger-ships. The few ocean freighters we had during the early nineteen hundreds that were operating in competition with foreign ships were withdrawn from the seas because of Federal legislation which made their profitable operation in competition impossible.

America was virtually a shipless nation when the World War came, except for a few excellent battleships. The Shipping Board, organized to foster ocean shipping and shipbuilding, was then authorized to build a fleet of merchant vessels to haul our numerous necessities to France. We built ships and more ships, such as they were, in 608 shipyards in the United States. These ships cost America about $4,000,000,000, but before we got many of them operating the war was over.

The failure of our Government to foster shipbuilding and shipping as needed is the cause of our present lack of foreign shipping by private interests. Today we have left in America only three private shipyards that can build a first-line battleship or ocean liner, and these yards are existing on work on small warships, barges, coasting vessels, and the like.

Marine engineers know that modern ocean carriers must be powered with Diesel engines. Four years ago the Shipping Board began the execution of a $25,000,000 program to dieselize several existing steamships. Some of these are now operating very satisfactorily. The cost of conversion, however, was higher than was expected. Most of the engines are of slow speed, with direct-connected propellers, and weigh about 400 to 500 lb. per hp. Three ships are now being converted to Diesel-electric drive to prove the feasibility along these engineering lines.

Ships that contain from 10,000 to 40,000 tons of material cannot be built like automobiles. Each must be designed for the service it is to perform, but we must have ships carrying the Stars and Stripes over the seven seas or we shall soon become a second-class nation.

[1] M.S.A.E.—President and chief engineer, Treiber Diesel Engine Corporation, Camden, N. J.

FIG. 1—DELIVERING LATEX IN TANK-CARS TO THE SPRAY PLANTS ON A MODERN RUBBER PLANTATION

Tire Production Progress

By B. J. LEMON[1]

DETROIT SECTION PAPER

Illustrated with PHOTOGRAPHS

EVERYONE interested in automotive matters is aware that tire quality has been improved as greatly as tire prices have been reduced during the last decade, but few know the factors responsible for the production improvements that have made these developments possible.

The author points out these numerous advances, as they have affected the work and the product of the tire company with which he is connected. Plantations have been established in the Far East to assure a supply of the desired grade of raw material under stable operating conditions. These are conducted by scientific methods, both as affects the growing of the rubber trees and the health of the native workers. Latex obtained from the trees is now dried by the spray process, which yields a pure, dry, uniform grade of rubber, giving long life to casings and tubes.

Construction of tire casings has undergone extensive changes in less than two decades, developing from the woven-fabric type to the web-cord form of fabric, the making of which is described. Pure rubber, with which the cord structure is impregnated, takes the place of cross threads, and the web fabric is delivered as a dry flat sheet.

Casings are now built by the flat-band method, which gives equal cord tension throughout the tire structure and employs, instead of the heavy iron cores formerly used to form the carcass for curing, air or water expansion-bags that hold the casing in the mold during the curing process.

Another important advance reviewed by the author is the use of the Banbury rubber-masticating machine, that delivers a rubber mix of uniform quality and density, thus assuring balance of the tire in which the rubber is used.

In conclusion, the power equipment in a modern tire factory is reviewed, and the author shows that the advancement in this department has kept pace with the development in other branches of the industry, so that each operation, from the tree to the tire, is now conducted on modern methods of high efficiency.

WITHIN a quarter of a century man-made rubber plantations have triumphed over Brazil's wild forests, plant breeding over natural selection, and stable government and the willingness to work over political instability and haphazardness of labor. As a result of American foresight and enterprise, the largest rubber plantations in the world, conducted on the most scientific basis, are owned and operated in the Far East by an American rubber company. These plantations will produce this year 26,000,000 lb. of the highest-grade rubber, and enough acreage is coming into bearing to increase this yield to 40,000,000 lb. in 1931. This is a gain of 54 per cent, whereas the average gain in consumption of crude rubber in America during this same period is estimated as 25 per cent.

As long ago as 1903 the company with which I am connected realized the potentialities of independent crude-rubber production. At that time South American crude rubber monopolized the field, for the Far-Eastern British plantations had not come into bearing.

[1] M.S.A.E.—Field engineer, tire development department, U. S. Rubber Co., Detroit.

Accordingly, this company obtained a concession of 30,000 sq. mi., or 19,000,000 acres, of rubber forests in the Brazilian state of Matto Grosso, with the view of applying scientific methods to the growing of wild rubber. However, on account of a revolution and the unrest which followed it, development of the Brazilian estate was abandoned.

In 1907 the company investigated the Far East, including the Philippines, as an area of rubber cultivation. Two years later work was started in Sumatra and the Malay Peninsula and has continued until the company's estate of 136,000 acres now represents an investment of $28,000,000. Although this estate supplies as yet only a part of the company's requirements, its location in the heart of the world's rubber-producing area makes possible the purchase and shipping of latex from adjacent high-grade-rubber growers, so that a large proportion of the company's needs is filled under conditions by which the quality of the final product is rigidly controlled, from the tree to the finished article. So far as I know, only one other American company, the Goodyear Tire & Rubber Co., has ventured into the field of rubber production in the Far East, with an estate of 50,000 acres, 20,000 acres of which are reported to be in full bearing.

Yield Increased by Scientific Sanitation

Clearing the land, breaking the ground, irrigating, fertilizing, planting, and cultivating are the difficulties to be overcome in turning a tropical jungle into a productive rubber plantation. Successful rubber production depends upon adequacy of dependable and economical man-power, and climatic and geographical facilities for obtaining raw material, and upon the development of methods which make possible the production and utilization of this raw material by labor and machinery.

Plantations were not established in the Far East by chance. To the natural advantages of climate and soil are added those of stability of government, protection for invested capital, and adequate sources of cheap labor. On the United States Rubber Co.'s plantation, 20,000 adult natives work within 10 deg. of the equator, under conditions so sanitary that the death rate among these workers is lower than the adult death rate in New York City. Beri-beri, cholera, and dyssentery have been eradicated. These 20,000 natives produce twice as much rubber as do double the number of employes in British India, on a little more than one-half the acreage.

But sanitation is not limited to human beings; men and trees alike must thrive if the average yield per acre is to be increased. Results obtained among the workers by the medical profession have been matched by mycologists in overcoming diseases of root, leaf and bark on 10,000,000 rubber trees. Sanitation anywhere, but particularly on a rubber plantation, is one of the basic principles of waste elimination.

Nor has production progress been confined to preventive measures. Rubber-tree breeding, like milkstock breeding, with the object of obtaining highly productive types, is proving to be scientifically feasible. As botanists believe that the ability to produce large amounts of latex is transmissible to the offspring of a high-yielding tree, they evolved a process called budding. Bud-grafts from high-yielding mother trees are grafted to small seedings. During this budding process, the susceptibility of the wounded tree-tissues to the attack of parasitic organisms is very great; for, in a hot, moist climate, destructive fungi are always ready to pounce on an open wound. The true gage of the yielding power of an offspring cannot be determined until the transplanted seedling is old enough—four or five years—to be tapped for a considerable period of time. Any latex abnormality of the mother tree, as to low rate of cure and tensile strength, must be watched so that such weaknesses will not be passed on to the seedlings through the bud-graft. Results obtained thus far indicate that, where true-breeding strains are established, the productive yield will be as much as a three-fold increase above the average. Surely, this is production progress.

Spraying Process Effects Production Economy

The romance of rubber production no more than begins when the latex, the source of crude rubber, is taken from the bark of the plantation tree. A brief outline of the years of struggle to bring virgin tropical latex to this Country reveals the simplicity with which problems that had been insurmountable for decades are sometimes solved.

Ten years ago, the principal aim was to make a crude rubber of a better and more uniform quality than had been produced before. As plantation rubber was made more uniform, attention was focused on the need of eliminating some of the steps in rubber preparation that were wasteful and also detrimental to the quality of the rubber. One of these steps was the coagulation of latex by acids.

Rubber latex, as it comes from the tree and is transported in tank-cars on a modern plantation, as shown in Fig. 1, consists of about 66 per cent water, 30 per cent rubber in minutely globular form, and 4 per cent non-rubber constituents. The extraction of the rubber from the latex, by means of the spray process instead of by acid coagulation, is one of the waste-eliminating advances that has been made in rubber pro-

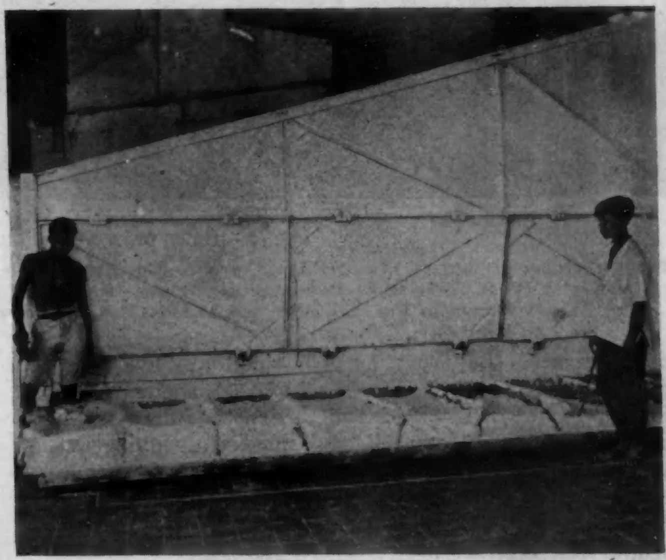

Fig. 2—Latex As It Leaves the Sprayer, Freed of Its 66-Per Cent Water Content

By a Centrifugal Process, the Pure-Rubber Globules Contained in the Latex Are Dried and Deposited, as a Cream-White Mass of Spongy Character, on the Spray Unit, Which Is Part of the Conveyor System. The Spraying Process Is Operated Continuously

duction. In this spray process the latex is directed in a thin stream upon a revolving horizontal disc, from which it is thrown centrifugally, as an umbrella-shaped spray, into a current of heated air. The water coating of the minute rubber globules is dried almost instantly, and the globules settle as a cream-white, spongy mass at the bottom of the spray chamber as shown in Fig. 2. The process is continuous, since the floor of the spray unit is a form of conveyor.

Close study of all methods of preparing crude rubber indicates that very careful consideration must be given to producing a clean and uniform product. Sprayed rubber is clean and seldom requires washing and drying. Uniformity, the master specification of all rubber compounders, is obtained because very large quantities of latex can be mixed in the storage tanks. Sprayed rubber is therefore a long step forward in production economy.

The American tire industry consumes more than 60 per cent of the world's rubber production, and its output for 1927 is estimated at 62,000,000 tires, valued at about $920,000,000. Motor-vehicle owners do not realize that tires probably are by far the cheapest article of widespread consumption that is sold to the public, considering the service they give. Tires today may be said to be selling at prices below a fair level, for the following reason:

The potential yearly tire production of the United States is at present not far from 82,000,000 casings. Extended over a period of 12 months, the peak monthly production attained during April, 1927, would result in an approximate yearly output of 73,000,000 tires. The actual production in 1927 is estimated at about 62,000,000. Thus, the industry is 25 per cent potentially "over-capacited," which accounts for the strenuous competitive efforts to effect economies and to eliminate waste in production methods.

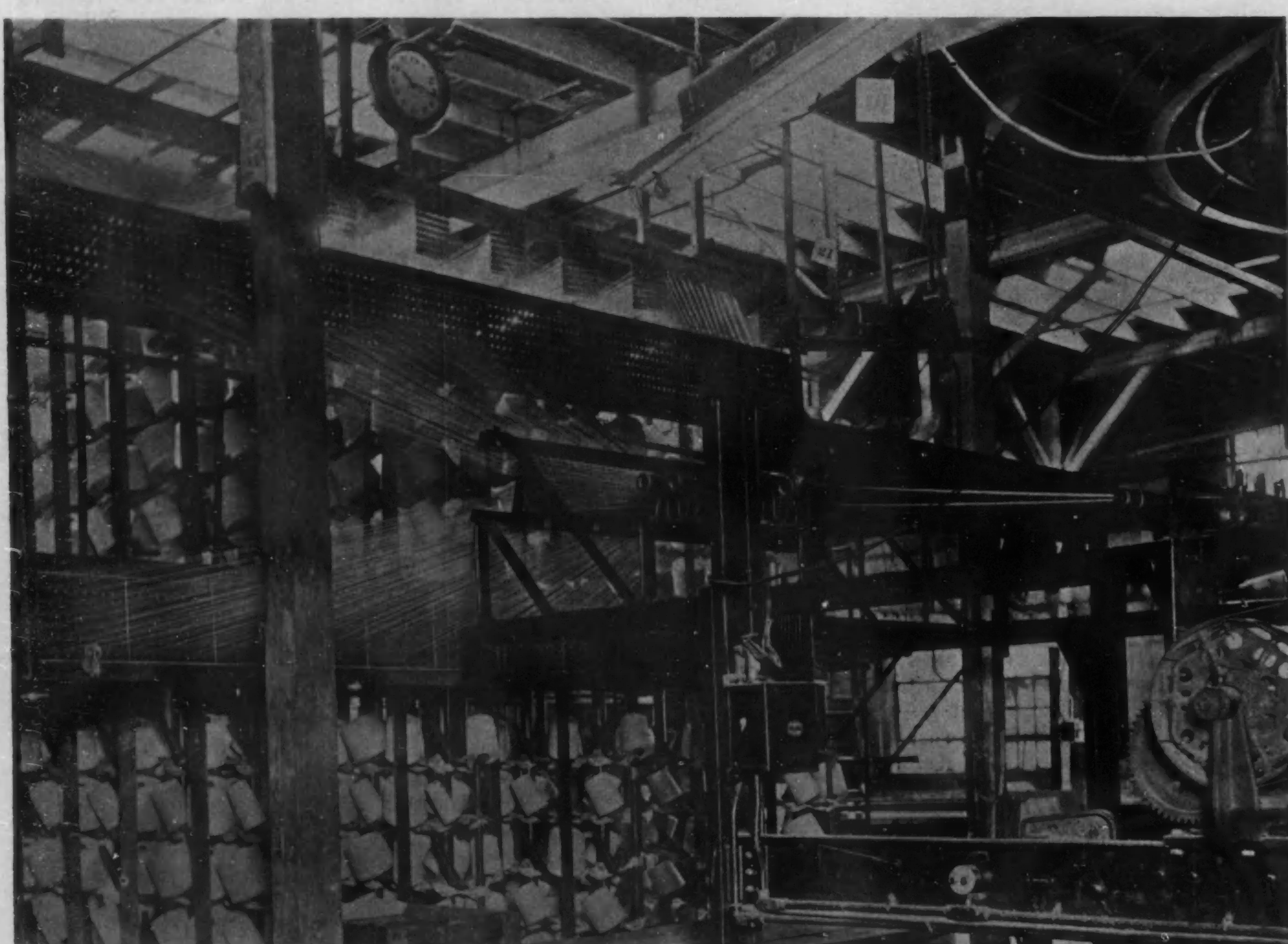

FIG. 3—PART OF A WEB-CORD FABRIC-FORMING MACHINE

The Requisite Number of Cotton-Fiber Cords to Go into a Web-Fabric Sheet Are Run from Cones Supported on a Creel, as Seen at the Left. From These They Pass through Thread-Boards and a Comb, at the Center, Prior To Being Impregnated with Latex As Shown in Fig. 4. This Method Has Made It Possible To Eliminate Cross-Threads in the Tire Fabric

Development in Cotton Tire-Fabrics

Persistent research has been carried on to find the best kind of fabric suitable for use as the skeleton for the tire. Every fiber which promised the barest chance for success was tried, but cotton survived all others. To cope successfully with the fabric problem, the United States Rubber Co., in 1916, designed and established cotton mills for the production of tire cord. These mills were located close to the source of supply, an important step which made possible the adoption

and control of manufacturing requirements needed to make a fabric that fulfills tire requirements. It afforded absolute control, by the tire manufacturer, of cotton as well as rubber from the soil to the finished tire.

One of the first economies forced by the intense competition in the tire industry was the fabrication of cotton fibers into cords each of which carries evenly its share of the load. The sound idea underlying the cord tire was to do away, as much as possible, with the cross weave or filling threads. Although it was necessary to retain an occasional weft thread, about five in every 2 in., so as to hold the cord together, the design and manufacture of cord fabric represented a long step in advance over the woven tire-fabric, and this is one of the prime reasons for the high mileage given by cord tires.

Once cord tires had begun to show their superiority, it became obvious that additional advantages, both in the methods of building and in the finished tire, could be gained by a cord construction without any cross weave. Experimental work was therefore carried on for several years, until the present web fabric was developed and its use made possible by the importation of latex.

Web fabric is constructed by running cords, sufficient in number to form the required width of sheet, from cones supported on a creel, through thread boards and a comb, where the cords are brought into parallel position. A photograph of this part of the process is reproduced in Fig. 3. Then the cords pass through a bath of latex, at *a* in Fig. 4, where they are impregnated. From the latex bath, the dripping cords, seen at *b*, go over drying rollers at *c*. When the cords are dry they are held firmly together, not by weft threads, but by the rubber deposited on them in the latex bath. This latex treatment gives the cords an impregnation of pure rubber that has not been subjected to the detrimental treatment which is necessary when hot rubber is pressed upon the cords by a calendering process or when rubber is dissolved in certain chemicals.

This direct use of latex for impregnating web word is a gigantic stride forward. Five years ago, tire builders seemed to have reached the limit of tire-life extension in the employment of cotton and rubber. Rubber was either squeezed into the cotton by mechanical

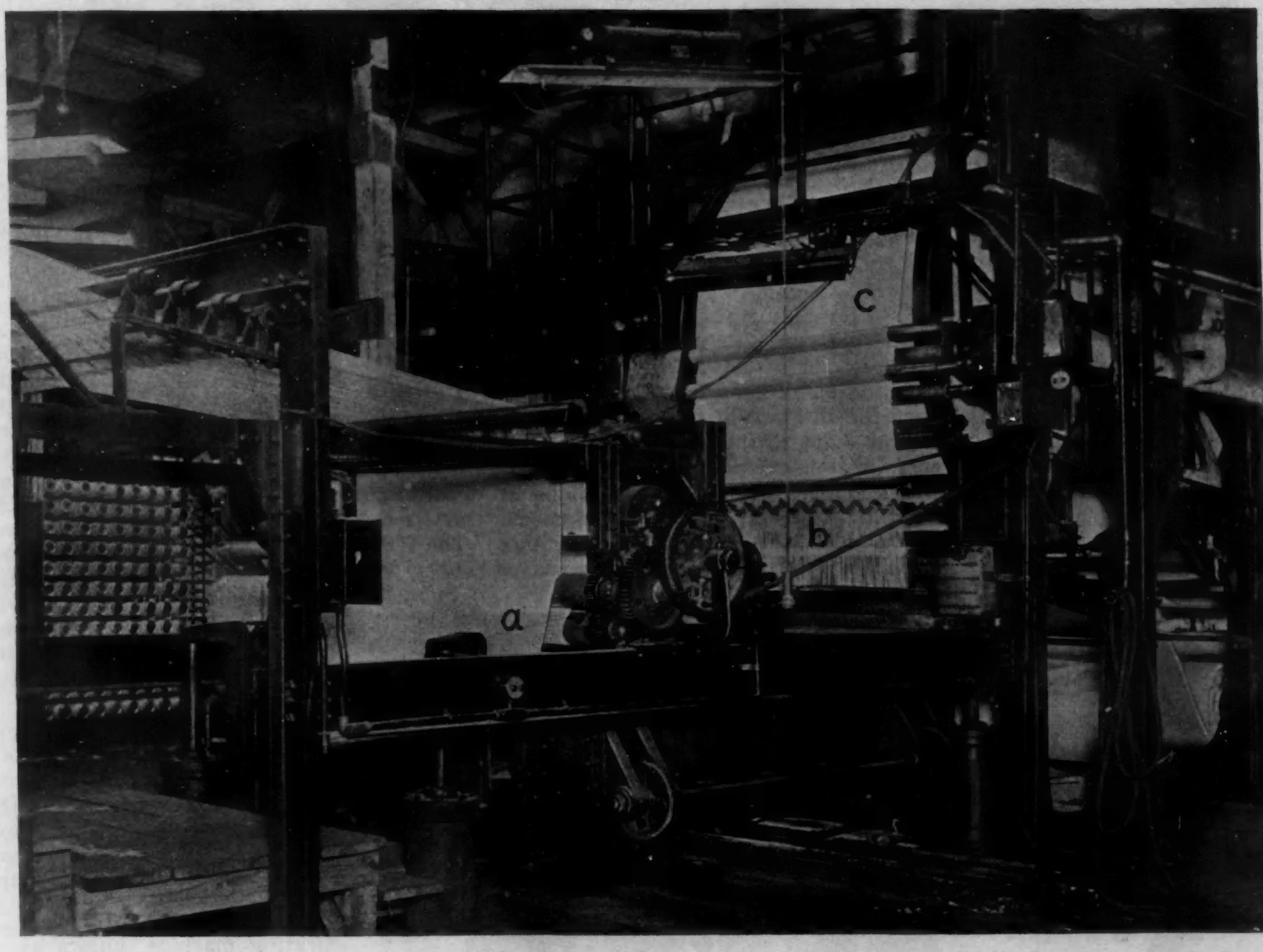

FIG. 4—RUBBERIZING THE CORDS TO FORM WEB FABRIC

After the Cords Are Laid Parallel and Close Together, As in Fig. 3, They Pass Down at *A* into a Virgin-Latex Bath. They Leave the Bath at *B* Dripping with Latex, After Which They Are Brought Closer Together and Pass Over Large Heated Drums, *C*, Which Completely Dry the Fabric and Leave It as a Sheet Ready for the Calender

means or soaked into it in the form of an artificial cement made of rubber dissolved in gasoline or a similar solvent.

Then web cord was supplied from the cotton mill and virgin latex from the tropics. Latex is a uniform solution that flows and wets like water, holding 30 per cent of pure rubber uncontaminated by acid, smoke or bark; whereas artificial rubber cement, containing as little as 10 per cent of rubber, is as thick as molasses. Under proper conditions, a greater percentage of rubber can be soaked into the cotton by using latex than if cement is used; moreover, the rubber is of high tensile strength and quality. When drying latex, water is vaporized; when drying cement, organic solvents are vaporized and their loss or recovery adds to the material cost.

Thus, latex, sprayed rubber, and web cord represent economies that affect the motorist's pocketbook.

Flat-Band Tire Building

A new principle of building tires, known as the flat-band method, has been gaining prominence for the last seven years until 50 per cent of all automobile tires are now made by this method. More than 40 companies, including several of the largest producers, are actively interested in the new principle. Until the flat-band method was developed, the operation of tire building was essentially the same for all kinds of tires. An iron core, made to the size and shape of the inside of the tire, was used. These cores were heavy and difficult to manipulate. The required number of plies of rubberized fabric were sketched or built up on the cores, the tension often varying with the physical strength of the tire builder, so that it was possible for a tire to have both tight and loose cords, resulting in unequal tension when the tire was inflated for use. Research was therefore directed toward a tire-building principle which would ensure equal tension on the thousands of cords in the tire.

It was found that, by building a tire in the form of a flat band, as in Fig. 5, and by subsequently bringing it to shape by air pressure, this result could be secured, as, during the shaping, each cord adjusted itself as to tension, angle twist and spacing. This adjustment was facilitated by the absence of cross weave in the fabric. Air or water expansion-bags made of rubber were then inserted into the shaped tire and pressed the carcass against the containing mold for the curing process.

The flat-band principle not only produces an equal tension on the cords and a balanced tire; it increases the rate and reduces the cost of production, eliminating at the same time the need of handling heavy iron cores by hand or machinery. It does away with all tucking of fabric about the beads, which is necessary in the core process, and its present rapid adoption in this Country for 6-in. tires and smaller sizes indicates its superiority over older methods from every production standpoint.

Masticating Machine Produces Balanced Tread Stock

With the advent of four-wheel brakes, balloon tires, good roads, and high-speed cars, the requirement of balance in automobile tires is now costing the industry millions of dollars in the balancing of original tire-equipment. One item in tire balance is uniformity of rubber mix. The recent introduction of machinery for masticating rubber, as a substitute for the older method of mixing the rubber and other ingredients between mill rolls, has added greatly to the uniformity of the specific gravity of the rubber stocks, and therefore to tire balance. A tread stock that is non-uniform in specific gravity after the calendering operation may produce an off-balance when the tread and carcass are united in the tire.

The most successful masticating machine, known as the Banbury mixer, which is shown in Fig. 6, uses larger batches than can be handled on mills, thus reducing weighing errors. The operation of the mixer follows a definite clock-dial chart. Whenever an operation should be changed or an ingredient added the need is indicated by a hand on the dial of the mechanism, which also charts the temperature of the rubber in the mixture. The whole work of mixing is recorded so accurately that the charts are used by the time-keep-

Fig. 5—Flat-Band Method of Modern Tire-Building

Instead of Shaping the Casting on an Iron Core as Was Formerly Done, Tires Are Now Built First in the Form of a Flat Band and Are Then Brought into Correct Cross-Section Shape by Air Pressure. Inflatable Rubber Air-Bags or Water-Bags Are Then Inserted To Hold the Casings to Shape in the Molds During the Curing Process

ing department to calculate the wages of the operator. A group of these recording dial-clocks can be seen at the upper left in Fig. 6.

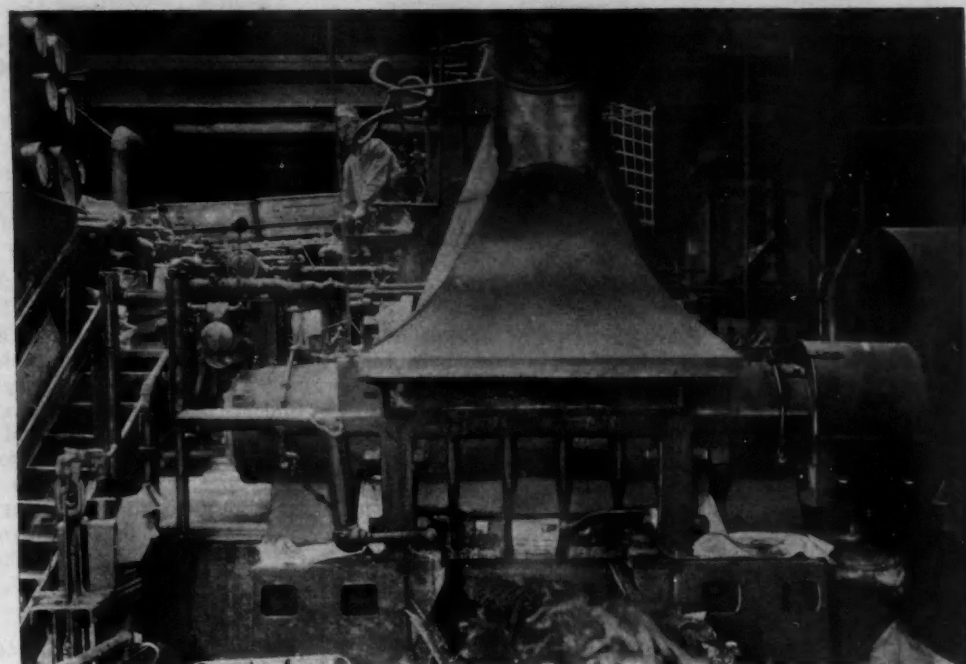

FIG. 6—THE BANBURY MASTICATOR THAT IS DISPLACING MILL-ROLLS FOR MIXING RUBBER COMPOUNDS

This Machine Handles Larger Batches of Rubber than Could the Old-Style Mill-Roll Mixers, and, by Reducing Weighing Errors, Results in Greater Uniformity of the Rubber-Mix. The Machine Is Equipped with Recording Clock-Dials That Show the Temperature of the Rubber and Indicate the Time for Adding Ingredients or for Changing the Operation

In old-time mills the results varied because of the human element and the absence of automatic controls. The Banbury mixer, by reducing these chances of error, adds another economy; no allowance need be made for variation in the rubber stock per tire, since the average and the minimum weights of our treads are almost the same.

Application of the conveyor system to tire and tube manufacture has done as much to speed up production as it has done in the automobile factory. Batches of rubber weighing hundreds of pounds are conveyed systematically from a compounding room to the mixing machines. Uncured tires move to the pressroom on the same conveyor that moves the curing bags to the shaping machines and carries the vulcanized tires to the final-inspection department. Heavy molds are conveyed mechanically to and from the presses. Automatically controlled magnets open these molds and lift the tires from them. Thus, conveyors have largely eliminated old methods of hand-trucking.

Because the power item in the modern rubber factory constitutes an appreciable percentage of the whole plant budget, opportunities for saving in the power department merit serious consideration. In our Detroit plant, the adaptation of modern highly efficient power-generating equipment to our requirements has resulted in economies more than commensurate with the capital investment.

Old-time reciprocating engines have given way to modern turbo-generators of the bleeder type. These new units supply ample steam for process work and for building and feed-water heating, while electrical energy is utilized more or less as a by-product. As a result, the cost of electrical power has been cut by approximately 50 per cent. Incidentally, these units are of a capacity which renders operation entirely independent of outside power for peak loads.

In the boiler department, the utilization of pulverized-coal-burning equipment, embodying in one compact unit of radical design all the latest developments in fuel-burning refinements, has made possible the production of steam at a cost 20 per cent below that heretofore attainable. This is the first installation in this Country of a unit of this type. The compactness of these new units, one of which does twice the work of one of the older type on the same floor space, means a 50-per cent saving in building construction and ground area, a not inconsiderable item in view of construction costs and real estate values obtaining in large industrial centers.

Virtually all the progress we have made in the fuller utilization of the energy of coal has occurred since the World War. These years cover the development of the fire-box, the growth of the practice of reheating steam, the beginnings of the regenerative use of steam, the introduction of the new types of high-pressure high-temperature boiler, the development of the new types of engine and the improvement of old types. As the world makes progress the industries must consolidate the gains made by the production engineers and the quantity experts of yesterday.

Year by year the load of work is being shifted from man-power to machine-power, with the result that the output of the average wage-earner in the tire industry has increased more than 200 per cent since 1914. The greater the output per man-hour is, the greater is the surplus of production that can be distributed to the worker. In the long run, increased production benefits labor, and the manufacturer seems to be justified in using such machinery and methods as have been described and in selecting men to match the requirements of the new processes. When it shall become possible to make all men realize the economic advantages of the scientific method over the rules-of-thumb method, and of accumulated facts and accurate conclusions over empiricism, the standards of production will be even more greatly advanced.

Self-Energizing Brakes

By John Sneed[1]

Annual Meeting Paper — *Illustrated with* Drawings and Chart

THE theory and characteristics of brakes of the Steeldraulic system are set forth and their application in practice is explained. Self-energizing brakes are said to be desirable because they allow large clearances, low pedal-effort and frictional coefficient and, if properly designed, give a high degree of efficiency with smooth uniform action.

To accomplish these results, the controls should deliver equal and accurate actuation to all brakes at all times, be designed to minimize the possibility of becoming inoperative on account of dirt and rust, require no servicing, be noiseless and of good appearance, and remain unaffected by climatic changes. Shoe design should allow very liberal limits and tolerances in wheel, axle and drum assemblies, without causing erratic brake-action or noises. The brake hook-up should follow the simplest line and use the least number of connecting links. Particular attention should be given to avoiding friction in the linkage and to keeping the linkage deflection small.

A BRAKE-SHOE should be designed so that it will be effective on the total periphery of the drum face rather than only across the diameter of the drum, for the periphery remains constant but the diameter of the drum may vary because of eccentricity. To accommodate itself to such eccentricities, the shoe structure should float and should possess a high degree of flexibility so that high-pressure areas will be avoided where the radius of the brake-drum is short. Fig. 1 is an exaggerated illustration of the application of this theory. The dimension *a* across the brake-shoe may change greatly without affecting the dimension *b*. It follows naturally that, inasmuch as increasing or decreasing dimension *b* governs the pressure per square inch exerted by the brake-shoe against the brake-drum, no appreciable change in pressure will occur because of the variation of *a*.

A high degree of self-energization is considered desirable for the reason that it allows liberal clearances between the lining and the drum, low pedal-efforts and large pedal-reserve, and, if actuated by a low mechanical advantage from the pedal, strongly resists locking, although it may be highly efficient. This characteristic is due to the fact that the shoe obtains most of its actuating force from the turning brake-drum and, when the movement of the drum ceases, this force becomes inoperative. When the force exerted by the actuating means becomes insufficient to hold the drum in a locked position, the drum immediately begins to move again. A highly self-energizing shoe-structure should allow a relatively large movement of the shoe, as compared to the pedal travel, because, to a great extent, this movement allows the shoe to follow the expansion of the drum under severe braking-conditions without a serious loss of pedal reserve.

It was thought desirable to design the brake adjustment of such a shoe structure so that it would increase or decrease the effective circumference of the shoe rather than operate through the actuating mechanism. Because it was not intended to use equalizing mechanisms in the brake hook-up, the adjustment should be positive and of micrometer precision. The brake-shoe should possess the same efficiency in the backward as in the forward direction.

It was felt that this type of shoe would require controls that were very accurate in the amount of movement transmitted to the shoe, especially as the expanding movement of the shoe-ends was approximately one-eighth of the pedal travel; and that any variation in the control movement from right to left or from front to rear would produce erratic brake-action.

The usual requirements, such as quietness, reliability, freedom from servicing, and ease of installation, were considered in control designing; but, to secure accuracy, which was considered of the utmost importance, the controls should not be affected by the rolling of the axle, lateral turning of the wheels, or spring rebound.

Conduit Control Adopted

Possibly my wide experience previously with Bowden-wire structures was the deciding factor in my choice

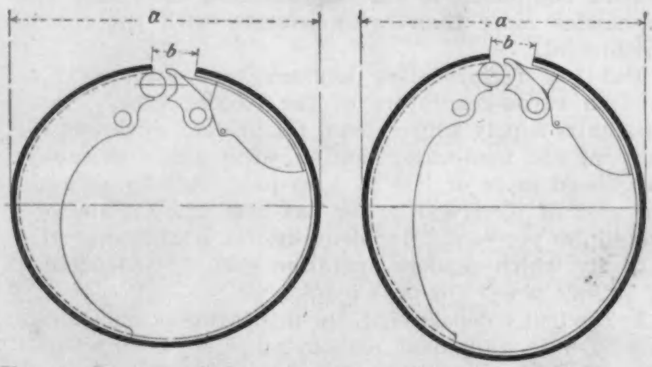

Fig. 1—Diagram Illustrating the Importance of Flexibility of the Brake-Shoe Structure

To Accommodate Itself to Eccentricities, the Shoe Structure Should Float, So That High-Pressure Areas Will Be Avoided Where the Radius of the Brake-Drum Is Short. In This Case, the Dimension *a*, Across the Brake-Shoe, May Change Greatly Without Affecting the Dimensions *b*. It Follows Naturally That, Inasmuch As Increasing or Decreasing Dimension *b* Governs the Pressure per Square Inch Exerted by This Type of Brake-Shoe Against the Brake-Drum, No Appreciable Change of Pressure Will Occur Because of the Variation of *a*

[1]M.S.A.E.—Consulting engineer, Midland Steel Products Co., Detroit; president, Steeldraulic Brake Corporation, Detroit.

of the conduit method of control; but, for various reasons, Bowden wires were found very unsatisfactory. To overcome the shortcomings of the Bowden wire, the Steeldraulic conduit was developed.

Fig. 2 is a diagram of a typical hook-up. This diagram shows the conduits, both front and rear, in their respective positions, bent through an arc of approximately 90 deg. and securely bracketed to the side-rails of the frame and to the backing-plate of the brake.

Fig. 3 is a cross-sectional view of the conduit and cable control. This control consists of two principal elements; a tension element, the cable, and a compression element, the conduit. The function of the compression element is to support the cable, while under tension, in a curved position, and to allow this curve to be changed or even discarded without affecting the tension to which the cable is subjected. The function of the cable is to transmit the desired actuation to the brake element.

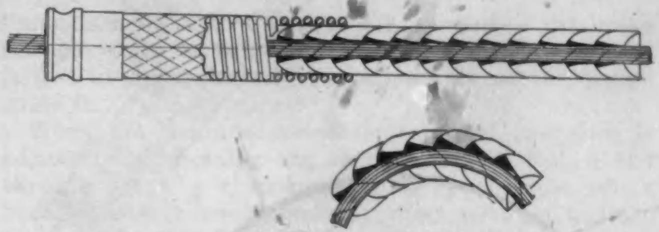

Fig. 3—Cross-Sectional View of the Conduit and Cable Control

The Control Consists of Two Principal Elements; a Tension Element, the Cable, and a Compression Element, the Conduit. The Function of the Compression Element Is to Support the Cable, While under Tension, in a Curved Position, and to Allow This Curve to be Changed or Even Discarded Without Affecting the Tension to Which the Cable Is Subjected. The Function of the Cable Is to Transmit the Desired Actuation to the Brake Element

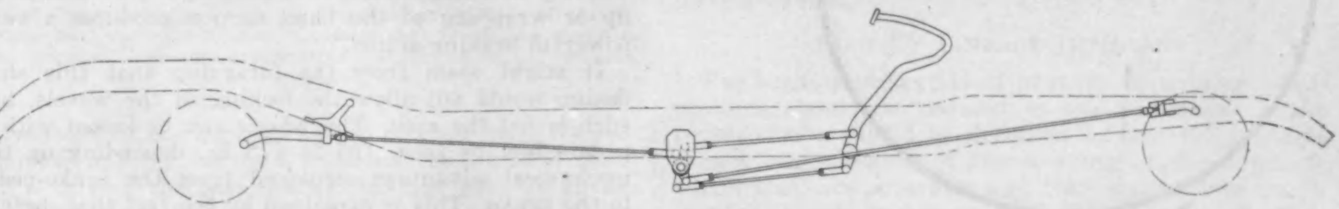

Fig. 2—Diagram of Typical Hook-Up

The Conduits, Both Front and Rear, Are Shown in Their Respective Positions, Bent Through an Arc of Approximately 90 Deg. and Securely Bracketed to the Side-Rail of the Frame and to the Backing-Plate of the Brake

Fig. 3 gives a clear idea of the structure of the conduit. The vertebræ are of steel in interfitting ball-and-socket sections. Bell mouths form lubricant chambers along the conduit. The vertebræ present a much larger bearing-area to the cable when the conduit is curved than when it is straight. This form was found necessary to prevent the cable's binding between adjacent vertebræ when the conduit is bent and to force a circulation of lubricant around the cable. The vertebræ are kept under constant compression by a heavy spring-cover. This spring, wound close-coiled, is stretched and into it are screwed the conduit terminals, leaving all vertebræ under a compression of about 50 lb. per sq. in. The spring also keeps the vertebræ in perfect alignment. The assembly is then covered with a waterproof boot. Lubrication is unnecessary after installation, for the conduit is packed at the factory with sufficient lubricant to last double the life of an average car.

The conduit, shown in Fig. 4, is disposed in a curved position between the frame and the backing-plate and can be considered as forming a flexible cable-supporting arch between the bracketing-points. This curve is necessary for the reason that the distance between points *c* and *d* is subject to considerable change. An increase or a decrease of this distance does not affect the tension of the operating-cable, since the cable is confined along the line *e e*, which is the bending line of the conduit. Any change in the distance between *c* and *d* serves only to increase or to decrease the arc in which the control is placed, without affecting in the least the length of the line *e e*, the true path of the cable.

In accordance with our theory, the shoe was designed as shown in Fig. 5. The arrows indicate the normal direction of rotation of the drum, and the direction of

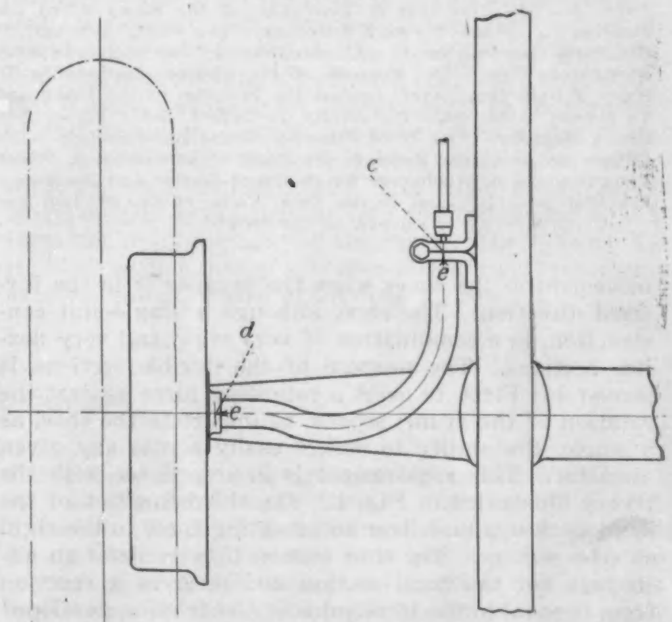

Fig. 4—Curved Conduit between the Frame and Backing-Plate

The Distance between Points *c* and *d* Is Subject to Considerable Change, But an Increase or Decrease of This Distance Does Not Affect the Tension of the Operating Cable Since the Cable Is Confined along the Line *e-e*, Which Is the Bending Line of the Conduit. Any Change in This Distance Serves Only To Increase or Decrease the Arc in Which the Control Is Placed, Without Affecting the Length of the Line *e-e*, the True Path of the Cable

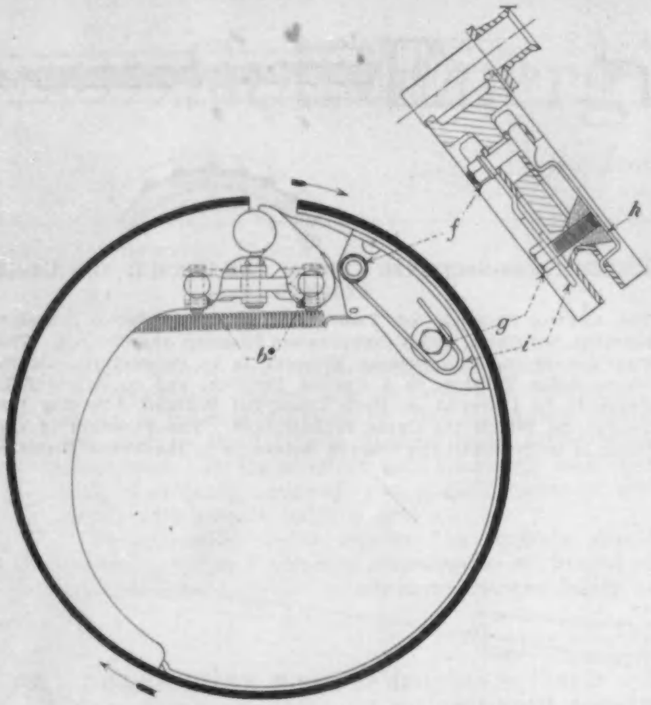

FIG. 5—DETAILS OF CONSTRUCTION OF THE SHOE

The Arrows Indicate the Normal Direction of Rotation of the Drum and the Direction of Movement of the Shoes When the Braking Is in the Forward Direction. The Shoe, Although of One-Piece Construction, Is a Combination of Very Rigid and Very Flexible Sections. The Purpose of the Flexible Sections Is To Exert a Retarding Force Against the Rotation of the Drum and To Impart to the Shoe the Ability To Deflect Easily across Any Given Diameter. The Third Function of the Band Section Is To Deliver an Actuating Force to the Rigid or Shoe Section, Which Thus Becomes an Anchorage for the Band Section and Receives a Reaction from It Equal to the Total Value of the Friction Developed on the Band

movement of the shoes when the braking is in the forward direction. The shoe, although a single-unit construction, is a combination of very rigid and very flexible sections. The purpose of the flexible sections is three-fold: First, to exert a retarding force against the rotation of the drum; second, to impart to the shoe, as a whole, the ability to deflect easily across any given diameter. This requirement is in accordance with the theory illustrated in Fig. 1. The third function of the band section is to deliver an actuating force to the rigid or shoe section. The shoe section thus becomes an anchorage for the band section and receives a reaction from it equal to the total value of the friction developed on the band.

This reaction might be compared to a motor-operated servo-device for operating the rigid-shoe section independently of manually operated means, except that it is entirely dependent on the efficiency of the manually operated band-section and at all times delivers a braking force in exact proportion to that developed by the band-section. It follows naturally that, since the band section is the only part of the brake that requires manual operation, and since this section is required to deliver only about 40 per cent of the total retarding or braking force, no difficulty is experienced in designing for large drum-clearances and shoe-movements.

Because of the fact that the expanding movement of each shoe is approximately one-eighth as great as the pedal-travel, it is apparent that the force exerted by the actuating means is not sufficient to generate or to develop a great amount of braking force through its own wedging action. It is powerful enough, however, to bring the short rigid section of the shoe into contact with the drum. This short rigid section, which is composed of the adjuster and the adjuster brackets, then serves to bring the band section into contact, and the band, in turn, serves the shoe section.

REVERSE ACTION AND ABILITY TO LOCK THE WHEELS

The action when reversing is, of course, somewhat different, for the rigid half of the shoe moves away from the anchor-pin and the shoe wraps in the opposite direction. However, the brakes are very effective in backing. Although a long rigid brake-shoe section is not very desirable as an energizing agent, the building-up or wrapping of the band section produces a very powerful braking-action.

It might seem from the foregoing that this shoe design would not allow the locking of the wheels, but such is not the case. The wheels can be locked with a pedal-effort of from 125 to 175 lb., depending on the mechanical advantage employed from the brake-pedal to the brake. This is explained by the fact that, before any great amount of retarding force has been exerted on the car, the leaf springs are distorted by the torque transmitted to the axle and, upon the wheels' locking. the springs transmit a reactionary torque to the axle and, therefore, to the brake-carrying member that keeps the brake snubbed into the brake-drum. Considering the powerful braking-force delivered, however, the shoe does resist locking to a marked extent. Fig. 6 gives a clear idea of the performance that may be expected.

This shoe has been found to be very smooth and dependable even when a lining having a frictional coefficient as high as 0.5 is used, although the mechanical

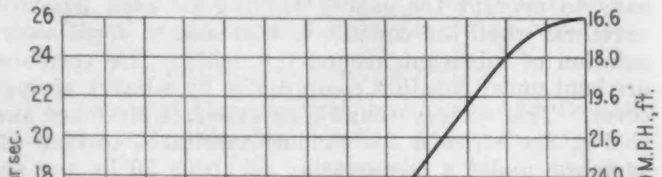

FIG. 6—CURVES OF PERFORMANCE, SHOWING THE RELATION OF DECELERATION TO BRAKE-PEDAL PRESSURE

The Shoe Has Been Found To Be Very Smooth and Dependable Even With a Lining Having a Frictional Coefficient as High as 0.5, Although the Mechanical Advantage of the Hook-Up Had To Be Changed. A Lining Having a Frictional Coefficient of about 0.3 Is Recommended as Giving the Best Results

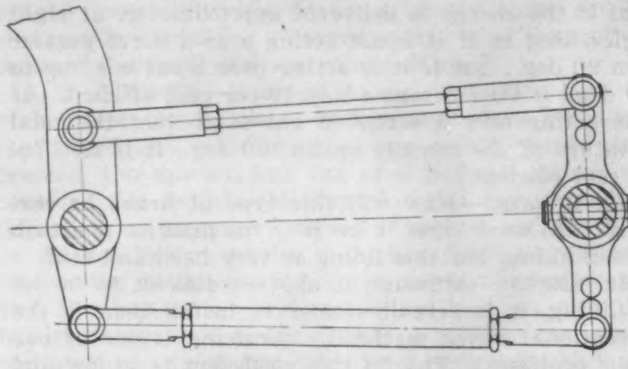

FIG. 7—TYPICAL ROCKER-SHAFT

The Balanced Couple from the Pedal to the Rocker-Shaft Obviates the Necessity for a Bracket To Take the Reaction of the Usual Pedal Connection, the Lower, or Compression Member, Transmitting a Backward Reaction to the Shaft that Is Exactly Equal to the Forward Reaction Transmitted by the Upper, or Tension, Member

advantage of the hook-up had to be changed. We recommend a lining having a frictional coefficient of about 0.3 as giving the best results, and our hook-up advantages are figured on this basis.

TOGGLES USED FOR OPERATING

Toggles were selected as the operating device, because they possess several distinct advantages in the operation of this type of brake. The toggles float with the shoe and operate in a plane at right angles to the plane of the shoe. By placing the toggles in this plane an expanding force in a straight line is obtained, as shown by the line *a a* in Fig. 5. This force has very little tendency to move the shoe radially in either direction, but causes it to move circumferentially with the drum.

The toggle pivots are not changed by adjustment of the shoe. The more powerful toggle-action caused by the flattening of the toggles through the wearing of the lining is compensated by the arrangement of the brake linkage, which is designed so that mechanical advantage is lost at approximately the same rate as the toggle gains it.

When the clearance becomes too great, the shoe is adjusted by loosening the clamp-bolt *f* in Fig. 5 and turning screw *g* clockwise. Screw *g* threads into a bronze wedge *h* which makes contact with an inclined face on both the shoe and the adjuster. Turning screw *g* draws wedge *h* between these inclined faces and forces the shoe into a larger radius, again establishing the proper clearance. Screw *g* is turned without removing the hairpin spring *i*, which acts as a safety device for the screw, each one-sixth turn of the screw adding exactly 0.015 to the circumference of the shoe. The flats on the screw head can be plainly felt through the adjusting-wrench.

HOOK-UP LINKAGE IMPORTANT

The hook-up linkage is of primary importance. Connections should be reduced to the minimum. Brake rocker-shafts should be designed so that the brackets cannot bind because of the weaving of the frame to which they are attached, and they should have cross-sections heavy enough to avoid torsional deflection, which would cause unequal braking. The front and rear brake-rod reactions should be balanced when practicable. In Fig. 7, a typical rocker-shaft is shown. The balanced couple from the pedal to the rocker-shaft obviates the necessity for a bracket to take the reaction of the usual pedal connection, the lower, or compression member, transmitting a backward reaction to the shaft that is exactly equal to the forward reaction transmitted by the upper, or tension, member. The rocker-shaft used is of 1⅛-in. diameter tubing with ¼-in. walls, with the ends counterbored. The end-brackets carry barrel-shaped plugs that fit into the counterbores and form the only bearings for the shaft. The tube cavity is filled with a heavy oil that offers good assurance against either freezing or binding.

THE DISCUSSION

C. P. GRIMES[2]:—What experience has Mr. Sneed had with different types of brake-lining on the brake-band?

JOHN SNEED:—Without taking the position of being too critical of the brake-lining manufacturers, we were practically forced to use molded material. About the only objection we have to the woven material is its variable coefficient of friction which, in a self-energizing brake, is an almost fatal defect since it is necessary to know what the coefficient of friction is before the brake can be designed properly. If the coefficient of friction varies it is difficult to design properly. We have found molded materials entirely satisfactory for this type of brake.

H. G. OTTMER[3]:—Would a hard-surfaced lining that does not absorb moisture to any great extent be satisfactory?

MR. SNEED:—I think it would be. However, we have found that more moisture penetrates woven material and to a greater depth than in the case of molded material. We think that is due to the structure of the lining, that is, to the way it is put together. In the woven material the fibers are parallel and are not broken up as they are in the molded material. For this reason, we find the molded material more satisfactory. It may absorb a small quantity of the moisture near the surface but that is largely a surface condition and it is not likely to penetrate deeper than possibly 0.001 in., and the moisture is dried out quickly by the heat of friction.

CHAIRMAN W. R. STRICKLAND[4]:—If moisture has such a great influence, why does the coefficient of friction need to be so low?

MR. SNEED:—I cannot see that there is any particular connection between the moisture content and the friction coefficient. We have successfully used a friction coefficient as high as 0.5. I tried to bring out the point that we cannot use a friction coefficient that may be 0.5 today and 0.3 tomorrow while still maintaining the

[2] M.S.A.E.—Owner and manager, Grimes Brake Engineering Service, Syracuse, N. Y.

[3] President, Automotive Maintenance Co., Detroit.

[4] M.S.A.E.—Assistant chief engineer, Cadillac Motor Car Co., Detroit.

same braking action throughout the entire range.

O. R. WIKANDER[5]:—Has any attempt been made in braking to use metal surfaces which are lubricated? In experimenting lately with frictional devices I find it very difficult to get a uniform friction coefficient with dry metal, but, with the aid of lubrication, the friction coefficient becomes much more uniform.

L. K. SNELL[6]:—What kind of lubrication can be used for that kind of brake which will still allow the different temperature requirements to be met?

CHAIRMAN STRICKLAND:—Most of our attention has been applied to keeping the oil out of the brakes and, if they were lubricated, I fear that we would have similar trouble in keeping the oil in. Recently I suggested that the engine itself is the ideal brake, because all the wearing parts are lubricated and the temperature is controlled by the cooling-water. That constitutes the nearest approach to braking on lubricated metal surfaces of which I know.

MR. OTTMER:—When using molded lining, can the pedal pressure be kept down so that it does not cause too much fatigue in driving in heavy traffic?

MR. SNEED:—Referring to Fig. 6, an initial braking force is obtained at a pressure on the pedal of 20 lb.; it then rises progressively to a deceleration of 26 ft. per sec. per sec. and a pedal pressure of 130 lb.

J. H. HUNT[7]:—When the brake-lining is worn to the point of needing renewal, how is the wear found to be distributed?

MR. SNEED:—The wear is distributed right across on either side of the shoe as indicated in Fig. 5. It is about equal on the flexible side and on the rigid side of the shoe. At first thought it might appear that the wear would be greater on the rigid than on the flexible side of the shoe but such is not the case. It is possible to wear the lining to a thickness of 1/16 in. before it needs renewing. At the top and at the bottom of the shoe the thickness would be say ⅛ in., but the wear diagram would be very uniform.

EFFECT WHEN ROUNDING A TURN

JOSEPH A. ANGLADA[8]:—Mr. Sneed stated that the retarding effect on the front wheels is about 15 per cent less than that on the rear wheels due to the friction of the cable in the conduit when the front wheels are turned. Assuming that the brake is applied in the straightaway position and that the wheels are then turned, is the retarding effect reduced? If so, what becomes of the force applied to the front wheels when they were in the straight-ahead position? Does turning the front wheels reduce the retarding effect on the rear wheels also?

MR. SNEED:—We would not consider the retarding effect reduced when the wheels are turned provided that the brake had been applied before the wheels were actually turned; but, if the brake were applied after the wheels have turned, the friction will increase in the front conduit to a point at which there will be 15 per cent less retarding effect on the front wheels than on the rear wheels. The conduit is about 95-per cent efficient if the energy is delivered approximately at right angles, that is, if it is not acting over a curve greater than 90 deg.; but if it is acting over a curve of up to 120 deg., it then becomes only 70-per cent efficient. If it is acting over a series of curves so that the total curvature of the conduit equals 120 deg., it is also 70-per cent efficient.

MR. GRIMES:—How will this type of brake be serviced? In many cases it has been the practice to attach molded lining, but this lining is very hard and stiff.

MR. SNEED:—Although it appears difficult to install the lining, it is actually easier to install than is the conventional woven material. Servicing is one of our minor problems. The friction coefficient is so low and the area of the lining is so great that one set of linings will last for from 40,000 to 50,000 miles. Our servicing arrangements have not yet been completed, but I think servicing will be done directly through the dealer and that, probably, we will furnish brake-shoes for replacing in preference to asking that they be relined.

UNIFORM FRICTION-COEFFICIENT DESIRABLE

T. P. CHASE[9]:—In designing brakes, we are governed by the principle that they should be made so that, no matter what type of lining may be installed, there will be no serious trouble. If a lining having a low coefficient of friction is installed, the resulting pedal pressure may be high. If a lining having a high coefficient of friction is installed, the result may be supersensitive brakes. These features have made the design of brakes difficult and have forced a more or less unsatisfactory compromise; but, if linings having a narrow range of friction coefficient can be assured, the difficulties will not be so great.

Mr. Sneed mentioned a curve of deceleration which indicates from 60 to 75-per cent self-actuation, and brakes which will show a similar curve would be very satisfactory and desirable. One modification of this curve which would make a more satisfactory brake would be to have the slope increase less rapidly above a deceleration of 16 ft. per sec. per sec. That is about the maximum rate of deceleration which is really comfortable and safe for passengers. Above that amount of deceleration there is a strong tendency to throw the occupants to the front part of the car, particularly if the slope of the curve is too steep. Pedal pressure should increase at a lower rate after a point in the curve is reached which corresponds to about the amount already stated.

I make a plea here for some attempt to standardize on a reasonable coefficient of friction for brake-linings. If a lining could be made to have a friction coefficient of 0.4 to 0.5, and all manufacturers of linings would maintain that value of friction coefficient, brake design would be very much easier and the user would get more satisfactory results.

MR. SNEED:—We have not tried to obtain a curve which will show a marked decrease in the efficiency after reaching a deceleration of 16 ft. per sec. per sec. We must deal nowadays with stopping a vehicle that is moving at very high speed and, although we can work the proposition out, we have not found it desirable because, for stopping from extremely high speed, the curve drops off at a deceleration of less than 16 ft. per sec. per sec. and the pedal is likely to "fade" under one's foot. The drum expansion is so rapid that the brake-shoe and brake-lining have no time to absorb heat and counter-

[5] M.S.A.E.—Mechanical engineer, ring spring department, Edgewater Steel Co., Pittsburgh, Pa.

[6] M.S.A.E.—Engineer, Detroit.

[7] M.S.A.E.—Chevrolet Motor Co., Detroit.

[8] M.S.A.E.—President, Anglada Motor Corporation, New York City.

[9] M.S.A.E.—Head of engineering test section, General Motors Corporation Research Laboratories, Detroit.

act the drum expansion. However, such a curve can be obtained by installing a curved spring-steel connection between the pedal and the rocker-shaft.

A. J. SCAIFE[10]:—It seems to me that each type of brake-lining has its place. Examples of these types are the folded and stitched, the woven, the woven and pressed, the molded, and the steel linings. When we consider the mechanical operation, we find ourselves limited as to pressure, amount of motion and the like, so we use linings having a higher friction-coefficient such as the woven, and the woven and stitched material. For the booster or self-energizing type we use the harder linings such as the molded or possibly the woven and pressed, which are very thick originally and are then pressed thinner. For the steel linings and metal-to-metal contact brakes which are operated by air pressure, we use different forms of application. But all types are suitable for some special purpose.

With a fabric lining of any kind which replaces a steel lining and where the same pressures are used, the life of the lining is short even if it does not cause the wheels to lock. We advocate the lubrication of metal brake-linings. There is no special system for applying the lubricant except that at the end of a run or at the proper greasing period a lubricant such as grease or oil is applied. It tends to produce a smoother operation, and to give longer life. I have known of metal-to-metal brakes which, under very good care, have lasted for 40,000 miles before relining. In the majority of cases we get about 5000 miles; but it is possible to get 40,000 miles with careful inspection, lubrication, and service.

MR. SNEED:—I agree with Mr. Scaife's remarks about lubrication. With the molded material, we use say 10 per cent of flake graphite, which provides dry lubrication. The graphite is uniform throughout the structure of the lining and this eliminates the need of having to service it. We admit that graphite is a mild abrasive, but it is vastly preferable to lining which does not contain graphite.

MR. OTTMER:—On the self-energizing brake, what effect does rain have on the application of the brakes; that is, what is the lubricating effect of water which has not really soaked into the lining but is on the surface?

MR. SNEED:—Water seldom gets into the brake-drums. The mechanical advantage and the efficiency of the brake system itself are sufficient to lock the wheels on a wet pavement even though there is a film of water between the drum and the lining. After the linings have been soaked, two or three normal applications of the brakes are sufficient to dry the parts to their normal condition.

MR. OTTMER:—When the car is backing, if the linings are wet can the car be stopped?

MR. SNEED:—Yes.

MR. GRIMES:—I have been operating a brake service-station for the last 3 years. I agree with Mr. Scaife that it is impossible for anyone to make a brake-lining that will be satisfactory for all cars. I have to carry in stock five different kinds of brake-lining and have to watch carefully to provide the most satisfactory lining for each car that comes in for repair. I find that it is of the utmost importance to shape the relined band into a perfect circle over a steel drum.

MR. SNEED:—With the self-energizing type of brake it is not necessary to have a perfectly round drum. We prefer unfinished drums, held within tolerances of ±0.15 in., because we get better frictional values to start with on an unfinished drum-surface.

Many people in the industry seem to think that we cannot use woven lining on the self-energizing type of brake. We can use woven lining as successfully as anyone else; but we do not use it because we have not found a woven material which comes up to our standard of brake-lining, and also for the reason that we find the molded material gives better results.

[10] M.S.A.E.—Chief field service engineer, White Motor Co., Cleveland.

Advertising and Prosperity

SOUND advertising is a remedy for faltering business not alone in spurring the profitable filling of buyers' present wants. We have come to see that the very development of our social structure depends upon the rapid enlargement of needs and the introduction of new products. Through the adoption of production economies, principally the greater use of power and the fruits of research, established industries constantly reduce the numbers of their employes per unit of product. The surplus workers thus thrown off by older industries must be absorbed into new ones; otherwise we shall have widespread unemployment, lowered standards of living, suffering, discontent. It is the rôle of consumer advertising quickly to introduce new products to a mass market and thus create new demands for surplus labor. The automobile, the motion picture, rayon and a score of like products could not have been made servants of our common life so quickly had it not been for the penetration of advertising into every nook and corner of this Country and through every purchasing level known to business.

Advertising's place in such development of new products is clear. What would be the price situation in the shoe, the furniture, the carpet, and other staple industries if they were trying to employ the men and money which have gone into the automobile, rayon and motion-picture business? New enterprises absorb surplus labor, create new purchasing power, stimulate consumer ambitions, render business profitable and make for social well-being. Advertising is the loud-speaker for development.

We can look with great hope on advertising's promise for the maintenance of prosperity. Advertising has an important rôle in widening the profit margin, in both industrial and consumer transactions. It removes products from unhealthy price competition, as fast as it can unearth distinctiveness in products and organizations. It reduces production costs by insistence, in the planning of campaigns, on conformity of goods to needs and on standardization and simplification. It reduces distribution costs by challenging unsound marketing programs.

Advertising works for the public as well as for the advertiser. It helps to stabilize industry, and thus employment and dividends. It emphasizes quality and use, which, with price, are sounder criteria of value than price alone. It assures, through price stabilization, the continued improvement of product and the development of new products to minister to the consumer's needs.—From an address by James H. McGraw at the Harvard Business School advertising awards dinner.

National Airways Engineering

Discussion of Frederick C. Hingsburg's Aeronautic Meeting Paper[1]

AIRPLANES now fly 16,000 miles daily over National airways, carrying mail and express. Some carry passengers. Twelve air-transport companies operate this system of transportation.

Under the Air Commerce Act of 1926, the public will be assured of the use of airworthy planes flown by competent pilots over safe airways in accordance with the prescribed traffic rules.

To date, 4120 miles of National airways have been lighted for night flying, and the lighting of 3400 additional miles next year is contemplated.

In the paper the author describes the procedure of the airways division of the Department of Commerce in locating and establishing landing-fields between airports on the airways; ground markers, beacons and signal lights; boundary markers and obstruction lights; route designation signs; and other provisions made for the guidance and safety of pilots.

Radio equisignal beacons have been established at Hadley Field, New Brunswick, N. J., and Bellefonte, Pa.; and a third is contemplated at Cleveland. A small airplane radio-receiver suitable for single-pilot airplanes used by the Air Mail has been developed commercially.

The Weather Bureau has established 34 upper-air meteorological stations and furnishes weather forecasts of flying conditions to the airports. Twenty-eight airways weather-reporters were supplying data to terminal fields along the Transcontinental Airway on June 30, 1927, and this service will be extended to other routes by the Bureau in the near future.

Radio telephone and telegraph are used for communicating weather information, reports of arrivals and departures of airplanes, emergency messages and other information between airports.

The airways division was established in the Lighthouse Service, and work in connection with air-navigation facilities has been assigned to the lighthouse districts. The extension and construction section of the airways division now has 16 licensed air pilots and 12 engineers. Maintenance of airways is provided for by expansion of district offices of the Lighthouse Service.

In the discussion, points raised are the 30-mile spacing of intermediate landing-fields between airports which were deemed a safeguard against unfavorable weather conditions rather than against the mechanical failure of the powerplant of the airplane; the design of beacon towers, 450 of which are in service without a failure to date; and the cooperation of the airport subdivision of the construction section, Airway Division, Department of Commerce, with airport builders and municipalities desiring information relative to laying out airports. Written discussion suggests the desirability of dispensing with radial runway indicators and substituting a single arrow indicating the best approach and take-off runway under no-wind conditions; the availability and use of incandescent lamps for field illumination and markers; and the value of an airport to a municipality.

CHAIRMAN W. L. LEPAGE[2]:—I believe that all of us realize there are complications to be overcome before regular passenger air-transportation is developed to the position of being a reliable service. A number of operators are working under contract with the United States Government, carrying the air mail by day and by night over regular routes, most of which have been laid out and lighted by either the Post Office Department or the Department of Commerce. One might ask these operators whether they are going to carry passengers on their routes, and if not, why not. I know the answer will be largely in the negative, that in general the time has not arrived when it is wise to launch into regular passenger air-transportation by night. This is primarily a problem of ground organization. If we are to carry passengers regularly by night in the air, we must have a well-established and efficiently operating ground organization. I bring out this point because we already have had a great deal of experience in night flying. The Post Office Department initiated that experience and it is now being amassed by individual operators. We still have to go further, however, in the development of reliable ground organization before we can carry passengers regularly.

I think the problem is more psychological than actual; that is, if a pilot, while flying with passengers at night when visibility is of necessity limited, runs into conditions which cause him to doubt his ability to reach his destination, he will choose the safer course of landing, because of his passengers, whereas, if he is carrying mail, he probably will rely upon his skill and take chances. That condition obviously will have to be overcome and its solution, I believe, lies entirely in ground organization and the laying out of proper airways and airway facilities.

SPACING OF INTERMEDIATE LANDING-FIELDS

ARCHIBALD BLACK[3]:—I regret that the Department of Commerce has adopted the 30-mile spacing for the intermediate landing-fields. This would necessitate the usual commercial operation being carried out at an altitude of at least 8000 ft. With a commercial airplane heavily loaded, it is not always practical to fly at 8000 ft.; 5000 ft. is better. Another point I should like to ask Mr. Hingsburg about is why the towers are calculated for a wind velocity of only 70 m.p.h. when that velocity is

[1] Chief engineer, airway division, Department of Commerce, City of Washington. The paper was printed in THE JOURNAL for November, 1927, p. 523. The original abstract of the paper is reprinted above, supplemented by a summary of the major points dealt with in the oral and written discussion.

[2] Jun. S.A.E.—Assistant to vice-president, Pitcairn Aviation, Inc., Philadelphia.

[3] M.S.A.E.—Consulting air-transport engineer, Garden City, N. Y.

frequently exceeded in certain parts of the Country. The standard practice in bridge construction, I think, is to calculate for a velocity of 100 m.p.h.

F. C. HINGSBURG:—The spacing of intermediate fields at 30 miles is based on the experience and the recommendations of the Air-Mail Service. The fields are laid out on 30-mile spacing to provide for bad-weather landings only. It is known that weather conditions hamper air transport probably more than anything else. Mechanical failures are regarded as secondary, and the 30-mile spaces do not provide for them. I think it is inconceivable and quite impossible, in our congested communities and considering the terrain throughout the United States, with its mountains and what not, to have intermediate fields located sufficiently close together to permit of pushing through on a schedule at say 300 or 500-ft. altitude and provide a safe gliding angle to a field at any point along the course. The cost of intermediate landing-fields is very high and, if they were located much closer together, the cost of the airway would be all out of proportion to the revenues that might be expected at the present time.

With respect to the towers being designed for a wind velocity of 70 m.p.h., those that have been erected, of which there are perhaps more than 450 at present, have never yet had a failure. The towers are inexpensive. We buy them in lots of 150 or 200 at a cost of $106 apiece.

MR. BLACK:—I think there was a little misunderstanding. I did not suggest a flying altitude of 300 to 500 ft., but said 5000 ft. That would necessitate assuming the ability to land in an emergency field from any point if the fields were about 20 miles apart instead of 30 miles.

EDWARD P. WARNER[4]:—It seems to me that this is a point that deserves further emphasis and discussion, because I have no idea that we shall ever be able to operate on any airways with the intention of keeping the airplanes always within gliding distance of an emergency field. All of us who do much flying find out that we have to get down to 1000 ft. a good deal of the time to keep landmarks on the ground in sight. The mail will be flown and passengers will be flown under these conditions. The responsibility is on the engineer and on the operators to provide equipment that will not fail suddenly, and this responsibility is being wonderfully well assumed and carried out. With powerplants and airplanes of modern design and properly maintained, sudden mechanical failure is almost unknown. The mechanical failure that we have to guard against is the kind that develops slowly enough to give a few minutes' warning that enables a pilot to reach a field at a distance of 12 to 15 miles from the airplane. If we assume that an airplane is to remain within gliding distance of a field, the danger will be increased more often than reduced, as it will be necessary to fly at a great altitude, with the consequent difficulty of keeping the ground in view and following the route in event of the weather thickening.

AIRWAY DIVISION ORGANIZATION AND COOPERATION

MR. HINGSBURG:—The construction section of the Airway Division is divided into several branches covering lighting, surveys, radio, weather information, and airports. Several pilots are assigned to the airport work and make a specialty of it. Municipalities interested in the development of airports, the examination of fields, expert advice relative to lighting, condition of fields, improvements and things of that kind, may call on us and we shall be glad to send a representative to advise with them to the end that the airports will be developed so as to function with the department's recommendations on airports of recognized ratings.

MR. BLACK:—In entering the airport field as distinguished from airways, will not the department get into the position of competing with firms in the Country that are at present laying out airports?

MR. HINGSBURG:—The Air Commerce Act provides for the sponsoring and fostering of air commerce. We find that many municipalities are interested in developing airports but do not know how to go about it. They write to us telling us about their interest and the department sends a representative to crystallize ideas as to what should be done. We recognize that some commercial engineers are doing airport work, and in many instances we put municipalities in touch with these people to work out their special problems. The advice we give is general and I think is well worth while and is a direct application of the Air Commerce Act.

USE OF RADIAL RUNWAY-INDICATORS

ARTHUR HALSTED[5]:—Mr. Hingsburg stated that the field is identified from the air by a white circle with indicators running out radially to the outside of the circle to show the direction of the runways. Since the boundaries of the field are clearly marked and an inspection from the air will usually disclose the best runway, the radial runway-indicators could be dispensed with if better use could be found for such a mark.

It is a decided safety precaution for all airplanes, at any time, to land and take-off in the same direction. When the wind is blowing, this direction is determined by the direction of the wind. When no wind is blowing, this landing and take-off direction is not so determinate. Would it not be advantageous to dispense with all the radial runway-indicators except one and let this one indicate at the same time the best runway and the no-wind landing and take-off direction? When the landing direction is not fixed by the wind, landings should be made toward the circle along the radial indicator. This direction is easily remembered if the circle is thought of as representing the front end and wings of an airplane and the radial indicator its fuselage and tail.

NEW INCANDESCENT FLYING AND FIELD LAMPS

S. G. HIBBEN[6]:—The work of making night flying as well as daytime air navigation safe, commercially feasible, and generally practical can, in a great measure, be attributed to the pioneering efforts of Mr. Hingsburg and his associates in the Airways Division of the Department of Commerce. What has been accomplished is a tribute to the ability of an engineering organization to obtain the enthusiastic and friendly cooperation of manufacturers who are giving to this subject their best talent as their contribution to transportation.

The outstanding factor in making air transportation commercially feasible is the night illumination of airways and airports. Unless 24-hr. flying is made safe and expedient, the overhead investment in equipment and personnel must mean excessively high freight and

[4] M.S.A.E.—Assistant Secretary of the Navy for Aeronautics, City of Washington.

[5] Engineer, Bureau of Standards, City of Washington.

[6] Manager, commercial engineering department, Westinghouse Lamp Co., Bloomfield, N. J.

passenger rates. The details of night illumination are well covered in the paper, but several of the following items may be of interest as indicating how rapidly progress is being made.

Not less than five entirely new designs of Mazda incandescent lamps have been perfected for night-flying operations. Each airplane can now be provided with a pair of wing-tip headlights in special conical projectors that enable a forced landing to be made in an emergency. For field illumination there have been contributed the high-efficiency concentrated-filament T-20 bulb, 1000 and 1500-watt lamps, 115-volt range; while more recently the 1500 and 3000-watt, 32-volt field floodlighting lamps are evolving. For large single units there can now be procured 5 and 10-kw. lamps, the latter being a veritable sun in its concentration of intensity.

From recent flying observations I have been led to conclude that field border lights should be arranged to flash simultaneously, with a very brief "off" period. It seems that a mercury switch-control gives the best promise on account of freedom from contact troubles and because mercury switches do not interfere in the slightest with radio reception. Further studies may disclose that a plurality or cluster of green approach lights will be preferable, possibly extended to form a green arrow pointing in the direction of the runway. As for red obstruction lights, I believe Mr. Hingsburg's studies have shown the need of these being arranged in vertical rows on such structures as transmission towers, chimneys, and even steep hills. A problem remains to be solved in connection with the maintenance of these red lights, particularly on inaccessible points, and one suggestion is the use of vertically directed floodlight beams with red 45-deg. mirrors at various elevations.

Municipal Airports an Immediate Problem

Now that the methods are at hand for constructing airways and airports, we may ask, Is this a city traffic problem? Is it a matter for immediate action?

Why the city should be interested in aviation progress is clearer when we consider that the establishment and maintenance of air routes to the cities is as far as the real supervision or jurisdiction of the Government extends. Each city is responsible for its terminal facilities, landing-fields and local beacons. Each city can and should at once establish a community terminal field, tying directly to the Government-established intercity or transcontinental airways. Nor can local civic organizations forget that developments are moving rapidly. Since considerable areas are involved and the terminal field should be accessible to the previously established avenues of traffic within the city limits, it is highly advisable that plans be crystallized and early action taken.

Mr. Hingsburg has described how terminal fields may be identified and marked. The roofs of adjacent buildings should be illuminated and on the tops of prominent structures along the air routes should be painted arrows pointing to fields, route numbers, and the name of the locality.

Tomorrow's airplanes may not be essentially different from today's but certainly they will be vastly more numerous. They will be safer, although today they are mechanically as safe as any automobile. They will be more luxurious and more roomy. A passenger, particularly the business man, will not hesitate to pay a transportation rate of 10 to 15 cents per mile when he considers the time saved. Volume of traffic decreases the mileage cost, for most of the cost is for initial equipment. There are no rights of way to buy, no grading, no road surfaces to pave, no rails, ties, bridges, or tunnels to provide and maintain, no grade-crossing accidents, and no tremendous labor personnel to pay. The civic terminal field costs but little more to maintain than a good park, less than a golf course or a ship's dock.

Some Service Applications of Airplanes

In planning for airplane traffic bear in mind the following among the many services that can be performed:

(1) Broadcast applications of insect poisons over orchards, grain fields and cotton fields. Many large-area applications of high-class fertilizers or seeds can, and undoubtedly will, be made from the airplane
(2) Patroling of inaccessible areas, as in forestry and the prevention of fires
(3) Transportation of food and medicine to districts isolated by storms and floods
(4) Police work by air to suppress smuggling and for the better control of crime, especially in rural districts
(5) Aerial photography of large areas, the cost of mapping which by any other means would be prohibitive
(6) Surveying for electric-transmission lines and rights of way across country
(7) Commercial advertising

A commercial airplane of average size can readily carry 1000 lb. of high-class freight. Granting an extreme cost of as much as $1 per mile flown, it is permissible to hope that perishable goods and high-value merchandise can be thus transported.

This Society is to be congratulated for its interest in aviation developments. The great moving fingers of light from the airway beacons are writing upon the night skies a promise of achievement in transportation that excites the imagination. No civic organization can afford to let the message pass unheeded nor remain blind to the fact that air commerce is looming large on the horizon. Civic terminal facilities must be built, else the community will shortly find itself as much isolated as though it were not reached by a railroad or a paved highway.

High-Speed Automotive Diesel Engines

By DR. WILHELM RIEHM[1]

ANNUAL MEETING PAPER — *Illustrated with* PHOTOGRAPHS, DRAWINGS AND CHARTS

HEAVY oils, from their very nature, are suitable for use by the Diesel method. The higher pressures of the Diesel cycle necessitate only an inconsiderable increase in engine weight, according to Dr. Riehm, which does not interfere with its use for automotive purposes.

Of the various ways of carrying the Diesel cycle into practice, the Maschinenfabrik Augsburg-Nürnberg has adopted the pressure-atomization method which, because of its great simplicity, is particularly adapted to use in automotive engines. The construction of both the earlier and the most recent M. A. N. oil engines is described, with details of fuel injection and control. Test results under various conditions are shown in curves, and operating characteristics and experience are recounted.

Economy and flexibility are found to make the Diesel engine a recognized competitor of the gasoline engine for vehicle propulsion, especially where fuel cost is one of the major items of expense.

PRIMARILY, the operation of high-speed light engines for the propulsion of both vehicles and vessels depends upon the use of easily volatilized fuel, such as gasoline, benzol and alcohol. Still, attempts have not been lacking to use also, for the light type of engine, other fuels such as have been employed very economically in heavy low-speed internal-combustion engines, the heavy oils which have contributed most to the development and popularity of the low-speed engine.

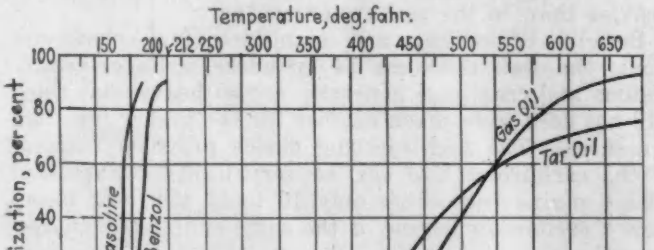

FIG. 1—VAPORIZATION CURVES OF LIQUID FUELS
Gasoline and Benzol, Which Are Suitable for Use in Carbureter Engines, Are Seen To Have Vaporization Characteristics Radically Different from Those of Gas-Oil and Tar-Oil

Considerations of economy probably have been the foremost reason for the attempt to employ these fuels also for light Diesel engines, both because the cost of the fuel is lower and because the methods evolved for the burning of this fuel assure its better thermodynamic utilization. Other considerations are the substantially smaller fire-danger and the larger range of action due to the higher efficiency of burning. The danger of carbureter fires is entirely precluded, and greater freedom is permitted as regards the storage of the fuel. Storing cars in buildings, for which very strict police regulations are in force in Germany, becomes less of a problem because of the lower flammability of the fuel.

It was natural that the manufacturers of carbureter-equipped engines first conceived the idea of changing from light to heavy oils merely by adapting the carbureter to heavy oil while keeping the engine in its conventional form. However, developments in this direction failed to give satisfactory results. The underlying cause is in the entirely different composition of the two kinds of fuel. As can be seen from Fig. 1, light oils and heavy oils exhibit essential differences in vaporization. While the fuels suitable for economical use with carbureters volatilize at low temperature and within a very narrow temperature range, the boiling curves of heavy oils cover a very wide temperature range and go beyond 360 deg. cent. (680 deg. fahr.).

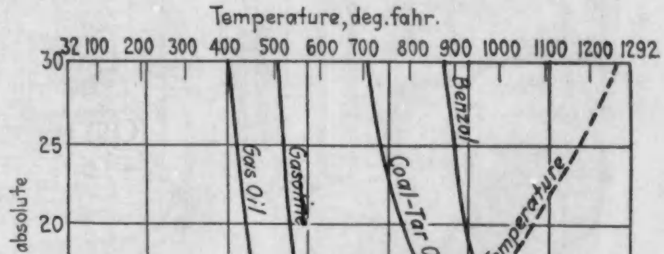

FIG. 2—RELATION OF IGNITION TEMPERATURE TO PRESSURE
The Four Solid Lines Show the Ignition Temperatures for the Various Fuels Named and the Dash Line Shows the Temperature in the Cylinder Due to Compression

[1] Maschinenfabrik Augsburg-Nürnberg, Germany.

Recent researches by Tauhs and Schulte on the ignition point of liquid fuels have thrown new light on the relation of the ignition point to the pressure. The results are indicated in Fig. 2. It will be noted that the ignition point for heavy oil at comparatively high pressure lies at a temperature at which a large portion of the fuel may have not yet been vaporized. Hence, complete vaporization below the ignition point is impossible. The liquid particles of fuel either are deposited on the walls, resulting in dilution of the lubricating oil, or they cause marked after-burning and lead to high exhaust temperatures and high fuel consumption. As can be seen from the curves, the ignition point of the heavy oils is below that of gasoline; hence, lower compression is imperative to prevent premature ignition. Thus the use of heavy oils in the carbureter engine meets with fundamental difficulties, because the compression would need to be raised, in view of the boiling-point curves, and the compression would need to be reduced, because of the low ignition point.

It follows that, because of the unfavorable properties of heavy oils for use with the explosion method, this fuel should be utilized by the Diesel method; that is, injection of the fuel into highly heated air, with spontaneous ignition. The lower ignition point promotes

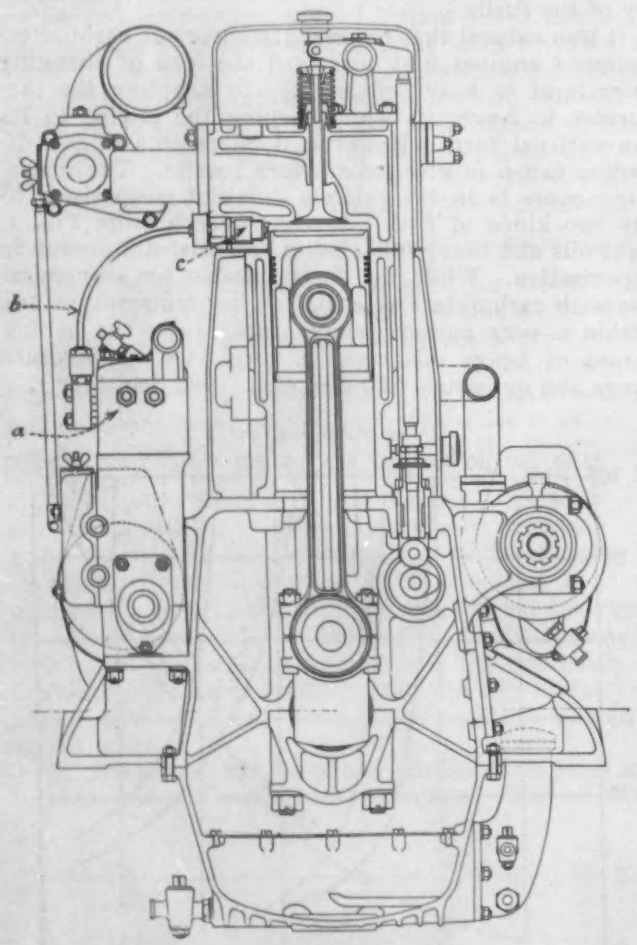

FIG. 3—CROSS-SECTION OF AN OIL ENGINE OF RECENT DESIGN

This Engine Has Cylinder Dimensions of 120 x 180 mm. (4.72 x 7.09 in.). The Injection Apparatus Is of the Same Design That Has Been Used for Several Years. The Units Are: Fuel Pump, *a*; Oil-Feed Pipe, *b*; Fuel-Injection Nozzle, *c*

spontaneous ignition, in this case, while the long boiling curve, due to the composition of the fuel, is necessary for quiet combustion. The spontaneous ignition of the fuel in the working air, however, requires substantially higher compression than is customary in carbureter engines, and this leads to higher ignition pressures and greater stresses on the working parts.

RELATIVE WEIGHT OF DIESEL ENGINE

The question may be asked whether these higher stresses are such that, because of the more rugged construction required, the weight of a light engine operated on the Diesel principle would be appreciably higher than that of the carbureter engine. If this question is to be answered first respecting the working parts, this must be done on the basis of the maximum pressures. In the case of carbureter operation, in which the explosion pressure cannot be controlled with the same certainty as in Diesel engines, the maximum pressures have been up to 28 atmospheres or more in recent designs. When using the Diesel principle, a combustion pressure of 42 atmospheres may generally be assumed for high-speed engines.

The diameter of the connecting-rod is governed by the maximum cylinder pressure, increasing with the fourth root of the pressure. Hence, raising the pressure 1.5 times increases the diameter of the connecting-rod 10 per cent and its weight about 21 per cent, presupposing a connecting-rod of circular cross-section. The dimensions of the crankshaft are based upon the maximum tangential pressure at a crank angle of 30 to 35 deg., and the crankshaft must be 4 to 5-per cent heavier than in the carbureter engine.

Because of casting and manufacturing considerations, the wall thickness of cylinders, cylinder-heads, pistons and crankcase generally are so heavy that they will not need to be made heavier for the higher ignition pressures. The fuel-injecting device provided instead of the carbureter also can be very light, so that the Diesel engine will weigh only 10 to 15 per cent more than a carbureter engine of the same cylinder displacement.

Since, in the vehicle engine, the weight is always related to the attainable power, one must investigate also how the power will compare in the carbureter engine and the Diesel engine for the same cylinder displacement. The power depends on the attainable mean effective pressure and the highest practicable speed. Carbureter engines usually attain mean effective pressures between 6 and 7 kg. per sq. cm. (85 to 100 lb. per sq. in.). In Diesel engines that have been in satisfactory operation on cars for years, mean effective pressures up to 6 atmospheres (88.2 lb. per sq. in.) are obtained normally with good combustion. At lower speeds, mean effective pressures greater than 7 atmospheres (102.9 lb. per sq. in.) can be attained for short periods. On the whole it can be said that the Diesel engine will hardly fall below the carbureter engine in driving torque.

Whether greater limitations are imposed upon the speed range of the Diesel engine cannot be decided now, but, with the same normal speed, the lowest speed at which the engine will ignite regularly probably will be the same as for the gasoline engine. Also the upper limit of around 2000 r.p.m., required for truck engines, probably can be reached without difficulty. From this it follows that, with the same cylinder volume, ap-

proximately the same power will be given by the Diesel engine as by the carbureter engine and the weight will be from 10 to 15 per cent greater for the Diesel engine, which would not prevent the use of this engine in vehicles.

Practice in the use of the Diesel principle in high-speed light engines has developed along various lines in Germany. The air-injection method, which has been used almost exclusively for many years in crude-oil engines, is less suited for the light type of engine. Because of the space and weight requirements for the compressor, particularly because of the greater demands for maintenance and operation, and also because the marked fluctuations in speed and load necessitate special provision for the regulation of the engine, this method is usually avoided. Still, a certain type of air-injection engine developed in Germany has proved successful for a number of applications, particularly in railway work.

Diesel engines for car propulsion in which no air is employed for fuel injection are simpler in manufacture and operation and lighter in construction. A number of different methods have been developed, and among these the antechamber system and the pressure-atomization system deserve most attention.

Antechamber injection has as its chief feature a chamber, placed ahead of the working chamber, into

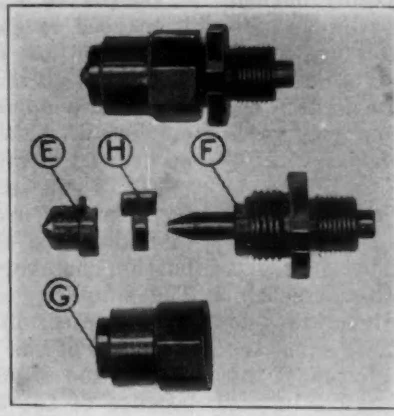

FIG. 4—FUEL-INJECTION NOZZLE
The Assembled Nozzle Is at the Top. Below Are the Parts: *E*, Nozzle Tip; *F*, Body; *G*, Nut, *H*, Collar

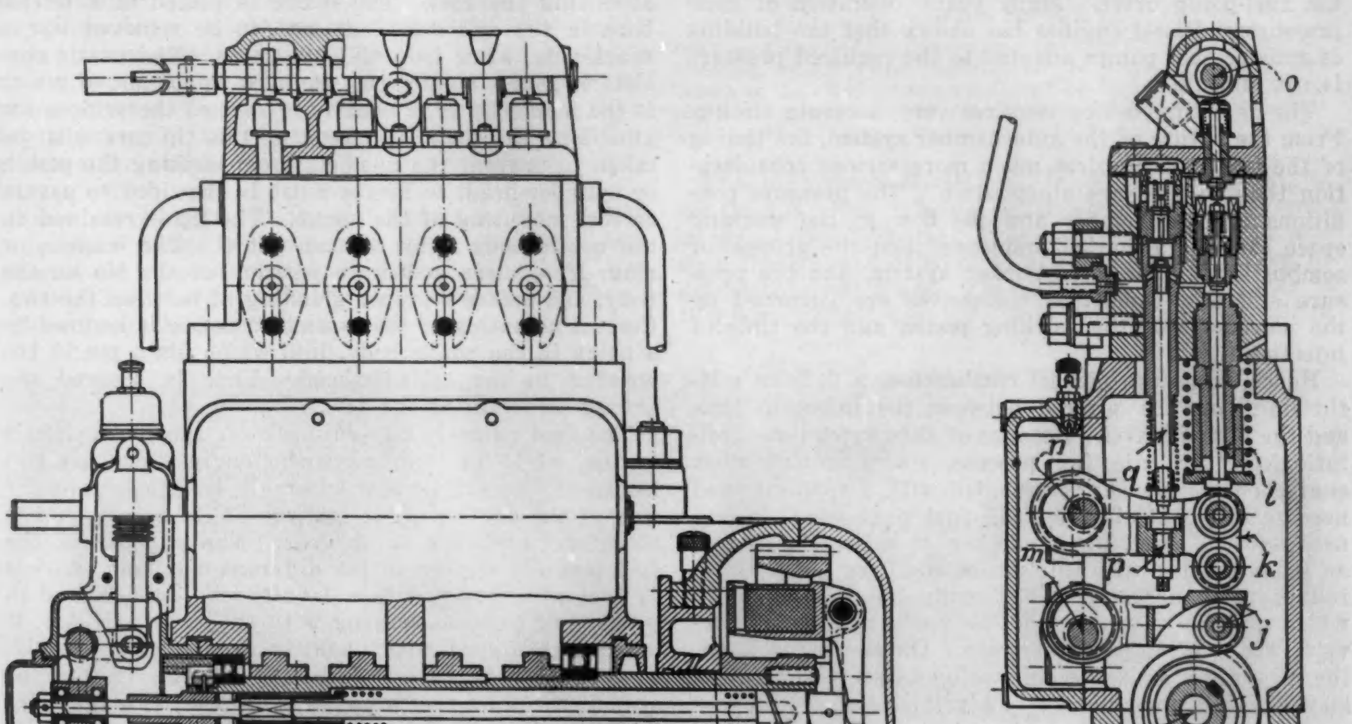

FIG. 5—SECTIONAL DRAWING OF FUEL PUMP
This Drawing Shows a Pump Serving a Four-Cylinder Diesel Engine. The Engine Governor Is Mounted in the Pump Drive Gear. The Parts Are Named and the Operation Is Explained in the Paper

which the fuel is injected and there partially burned. The pressure produced in the antechamber by the partial combustion being greater than the pressure in the main combustion space, the fuel-and-air mixture is blown through ports into that space, where it is mixed with the working air. Generally the compression is about 35 atmospheres and the combustion pressure 40 atmospheres.

The pressure-atomization method is distinguished from the preceding method primarily by the fact that the fuel is injected directly into the combustion space. The elimination of the antechamber leads to an essential simplification of the cylinder-head construction and permits the adoption of large valves. To be sure, the energy required for the distribution and mixing of the fuel must be imparted to the jet of fuel itself in the pressure-atomization method, so the fuel must be injected at higher pressure, commonly about 300 atmospheres in the fuel line, while 100 atmospheres usually is adequate with the antechamber system. But the increase in fuel pressure is insignificant in its effect on the fuel-pump drive. Many years' operation of compressorless Diesel engines has shown that the building of reliable fuel pumps adapted to the required pressure is not difficult.

The injecting device requires very accurate timing. From the nature of the antechamber system, the timing of the injection requires much more serious consideration than in pressure atomization. The pressure conditions in the chamber and the flow to the working space exercise a marked influence upon the process of combustion, in the antechamber system, and the pressure and flow conditions themselves are governed by the movement of the working piston and the time of injection.

Hence, to assure perfect combustion, a definite relationship must be secured between the injection time and the piston travel. Because of this strict time limitation of the injection process, every antechamber engine on the market is provided with a spring-loaded needle-valve controlled by the fuel pressure. Such a needle-valve, involving a number of delicate parts, is an inconvenience in manufacture and does not promise reliability in operation. Especially the nozzle tip, in which are the valve-seat and the ports, and the needle-valve are subject to great wear. On the other hand, the pressure-atomizer system is operated with what is known as an open nozzle. This injection device possesses marked simplicity, since it involves no moving parts subject to wear, excepting the fuel pump.

Pressure-Atomizer Engines Start Easily

Apart from their greater simplicity in construction and operation, engines equipped with pressure atomizers have a great advantage for cars because of better starting conditions. At a compression pressure of about 25 atmospheres an engine working with a pressure atomizer will generally ignite without any special aids, and hand starting is feasible because of the relatively low compression. Preheating the air charge is desirable for starting only when the outside temperature is very low. In spite of their higher compression, all antechamber engines now in the market have special provision for starting, such as ignition paper, ignition cartridges, electric heating coils and the like. Ease of starting is of decisive importance in choosing between these two methods for car engines.

In the M.A.N. four-cycle car-engines, which have been used extensively during the last 2 years for the propulsion of vehicles, the pressure-atomizer system has been given preference. According to conditions, either two opposing nozzles or a single nozzle can be employed. Also the whirling of the combustion air can be utilized to impart a circular motion to the charge.

Fig. 3 is a section of an M.A.N. fuel-injector engine. By means of a cam-operated pump *a* the fuel is taken in and forced through the open nozzle into the combustion-chamber under a pressure of 300 atmospheres. The simplicity of this arrangement is striking. The lateral injection results in a particularly simple construction of the cylinder-head, it leaves room for large valves, and it offers special advantages in car engines because of the convenient location of the nozzles. A particularly favorable feature is that there is no chance for the formation of air pockets because the fuel rises constantly from the pump to the combustion space.

Fig. 4 shows the fuel nozzle, of a design that is made in several types differing only in the fine orifices for atomizing the fuel. The nozzle is placed in a lateral bore in the cylinder-head and can be removed like a spark-plug, after loosening two nuts. The nozzle consists of four simple parts, the most important of which is the nozzle tip *E* in which are formed the orifices for atomizing the fuel. In mounting this tip care must be taken to prevent the fine jets from striking the piston or cylinder-head, so means must be provided to assure correct mounting of the nozzle. The tip is retained on the nozzle body *F* by the cap nut *G*. The washer, or ring, *H*, assures a definite position of the tip on the body, and makes a proper grinding fit between the two. Correct mounting of the assembled nozzle is assured by a notch in the nozzle body, into which fits a pin in the opening in the cylinder-head. Thus is assured the proper direction of the jets.

The fuel pump is cast in block for the four-cylinder engine, while for the six-cylinder engine there are two blocks of three cylinders each. It is attached to the side of the engine, about midway of its height, and is therefore accessible in the car. The purpose of the fuel pump is to feed to the different cylinders charges of fuel corresponding to a definite load, at a very definite crank position varying with the speed. Hence, it must be equipped with quantity or admission regulation that can be adjusted manually by the operator or attendant, or by the governor, and also with ignition-time regulation arranged to be adjusted manually, whenever operation is to be at very high or very low speed for any considerable time. Ignition adjustment is not necessary, but it is desirable for economy and smooth running of the engine. Its influence shall be discussed more in detail in connection with tests.

Control Is Through the Fuel Pump

Admission control is effected by suddenly opening a bypass valve during the delivery stroke of the pump, thus releasing the pressure in the delivery pipe. This occurs early in the stroke when the engine is running light, and late when running under full load. At the instant the overflow valve acts, the check-valve of the fuel pump closes under spring-pressure and the pressure prevailing in the engine cylinder.

The fuel pump is illustrated in Fig. 5. To provide regulation of both power and ignition time, the motion from cam *i* is transmitted through two levers, *j*, *k*,

which are fulcrumed on eccentrics, to the pump plunger *l*. Eccentric *m* of the lower lever causes a practically horizontal displacement of the roller on the cam and thus an earlier or later stroke of the plunger; in other words, early or retarded ignition. Eccentric *n* of the upper lever is shifted in an almost vertical direction, and thus changes the clearance between the set-screw *p*, in the lever, and the bypass valve *q*, in the pump body. The end of the useful stroke of the pump is governed by lifting the bypass valve off its seat sooner or later in the stroke, according to the position of the upper eccentric. The fuel admission of the different cylinders will be uniform if the clearance between the overflow valve and the set-screw is the same, in the same relative crank position, for all cylinders. This also provides a very simple adjustment for the fuel pump. The fuel is taken in through a spring-loaded suction-valve above the pump plunger, which can be withdrawn upward for re-grinding. In the two-spray arrangement, the check-valve is located in the fitting where the pipes branch off to the two nozzles. In the head of the fuel pump there is supported a shaft *o*, which, by means of staggered eccentrics, renders one or more of the cylinders inoperative by depressing the suction valves, so that the driver can determine while running whether the load is evenly distributed among the cylinders, or which cylinders are operating less effectively.

The control rod from the governor mounted in the drive gear passes through the pump camshaft and actuates the upper eccentric through a bell-crank and a rack. The valves and pump plungers are hardened tool-steel and the pump liners are cast iron.

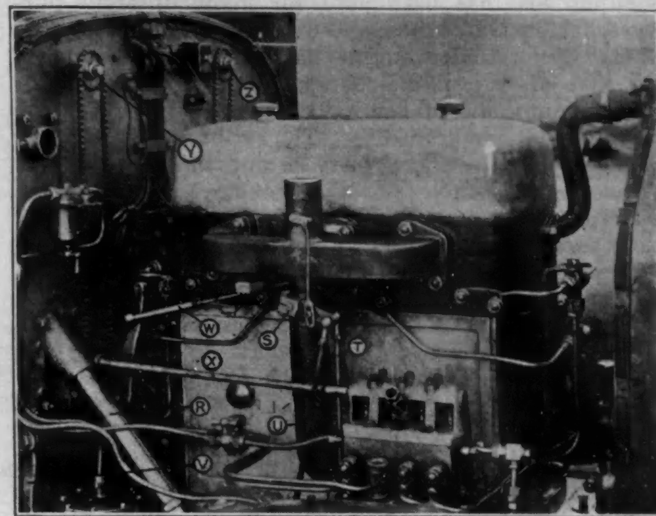

FIG. 6—FOUR-CYLINDER DIESEL ENGINE INSTALLED IN A MOTOR-TRUCK

The Fuel Pump and Its Connections Are Shown in the Foreground, Including an Oil Filter Mounted on the Dash. Sprockets and Chains on the Dash Control the Unloading Cams for the Oil Pump and a Compression Relief for Starting. The Reference Letters Are Explained in the Text

The high-speed Diesel vehicle engine first sold by the M.A.N. has 115-mm. cylinder-bore and 180-mm. stroke (4.53 x 7.09 in.). It is built with both four and six cylinders, and delivers 45 and 68 hp. respectively, at a speed of 1000 r.p.m. The weight of these engines is 10 kilos (22 lb.) per hp. This type of engine, which

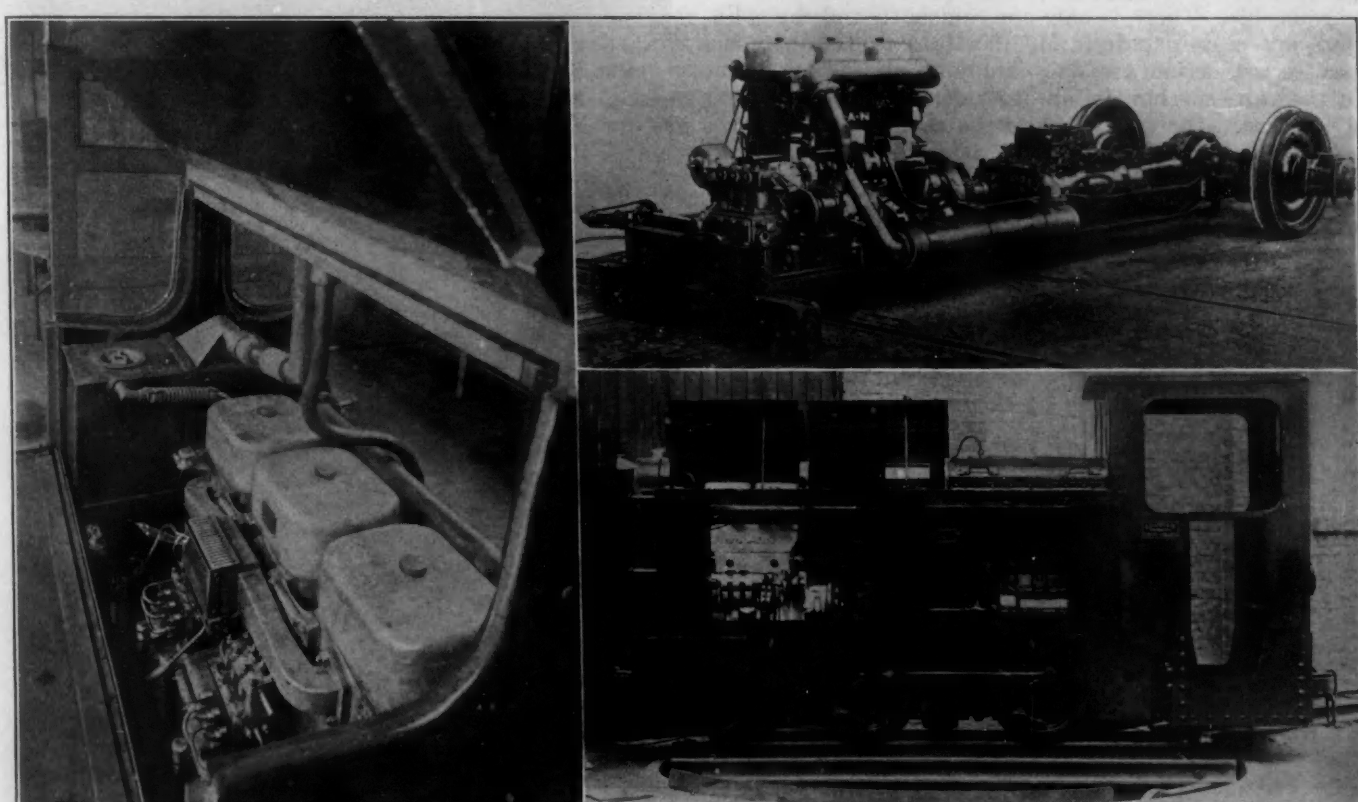

FIG. 7—DIESEL ENGINES IN RAILWAY SERVICE

A Six-Cylinder Rail-Car Engine Is Shown Installed in the Car, in the View at the Left, and Connected to Its Transmission and drive Wheels, in the Upper Right View. The Lower Right View Is of a Four-Cylinder Engine in a Small Locomotive

is suited and has been used for many different purposes, is illustrated in Figs. 6 and 7. The crankshaft of the four-cylinder engine has three roller-bearings, and that of the six-cylinder has four roller-bearings. In the aluminum crankcase are separate camshafts for the inlet and exhaust valves. The cylinders of the four-cylinder engine are cast in block and those of the six-cylinder engine in pairs. Cylinder-heads are attached to the cylinders by studs. Aluminum pistons are used and there are dust-proof aluminum covers over the engine, as shown in the photographs.

A starting motor usually is provided with the engine, but for manual starting the exhaust valves can be raised from their seats by a shaft *Z*, shown in Fig. 6. For starting after the engine has been standing idle in the extreme cold, air must be preheated for reliable ignition. The inlet pipe is provided with a butterfly valve to throttle the cold air while the engine is running idle or light, heated air being drawn from the exhaust pipe. This arrangement can be seen in Fig. 6.

New Models Embody Experience

After several years' experience had shown that there is a wide field of application for car engines of this type, the design of a new model was begun, to incorporate the results of the experience gained in design and construction. This improved model, a cross-section of which is shown in Fig. 3, has a cylinder bore of 120 mm. and a stroke of 180 mm. (4.72 x 7.09 in.). The four-cylinder engine has five crankshaft bearings and the six-cylinder has seven. The engine has forced lubrication. After removing the oil-pan, the crankshaft can be removed from below. Since the working parts are more rugged, speeds up to 1500 r.p.m. are permissible. There is only one camshaft, and the cylinders are cast in pairs. Modifications of the cylinder-head construction are due chiefly to the arrangement of the valve mechanism on one side. Inlet and exhaust pipes are on the side opposite the camshaft.

Another more powerful model has a cylinder diameter of 165 mm. and a stroke of 220 mm. (6.50 x 8.66 in.). This model is intended chiefly for rail-car propulsion, small locomotives, dredges, and marine work. This engine, illustrated in Fig. 8, is built with both four and six cylinders, the power being respectively 120 and 180 hp. at 1000 r.p.m. The crankshaft is supported in plain bearings, similar to the model last described, and pressure lubrication is provided. The crankcase, as shown in Fig. 9, is of different design. It is made of cast iron and is brought up to the cylinder-heads and the aluminum pistons run in separately cast liners. Openings are provided in the crankcase through which

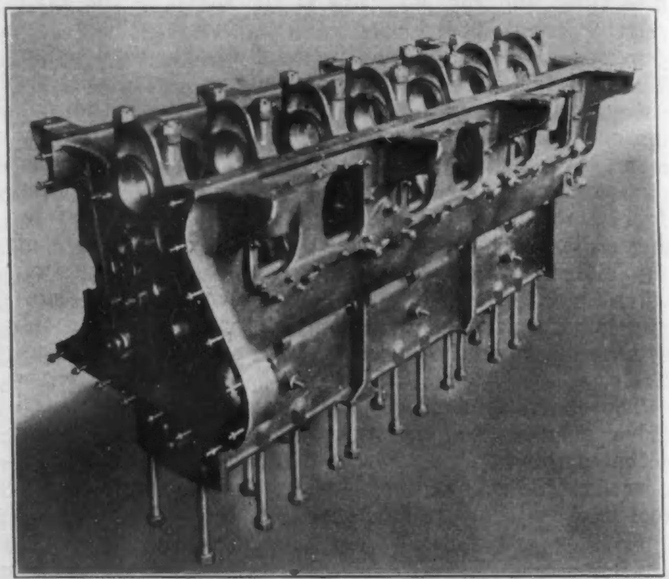

FIG. 9—CRANKCASE OF THE ENGINE SHOWN IN FIG. 8
This Crankcase Extends from the Oil-Pan to the Cylinder-Head. The Pistons Operate in Cylinder-Liners

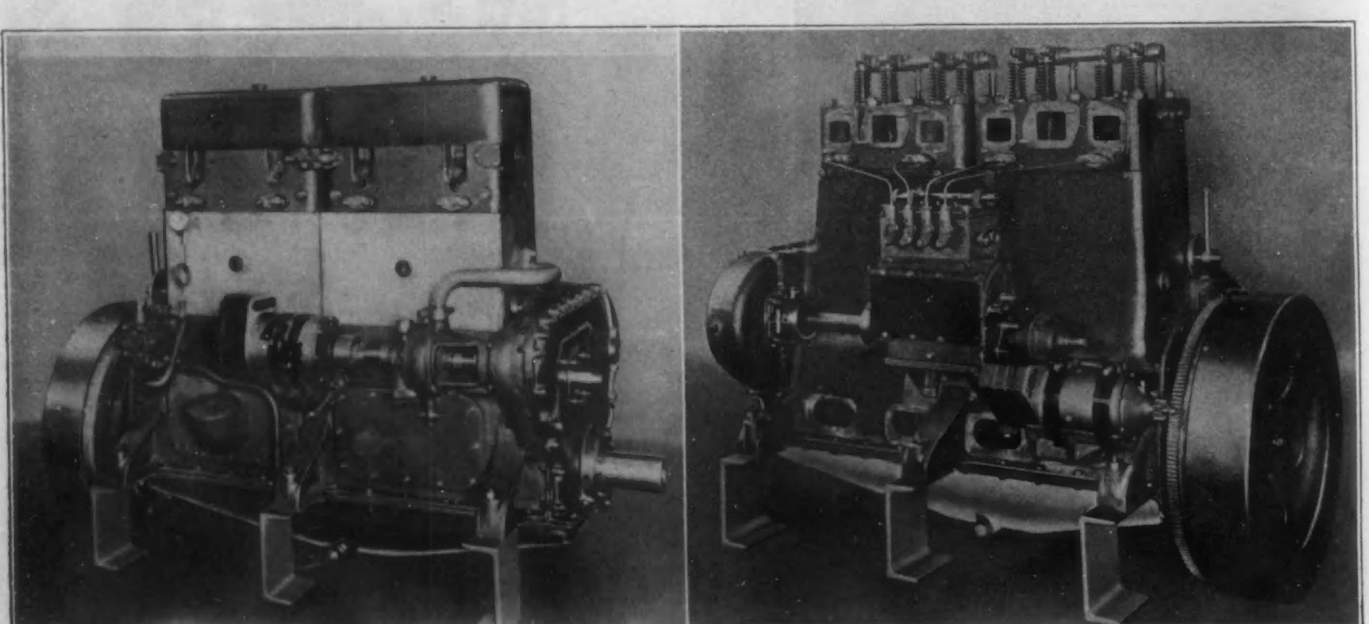

FIG. 8—FOUR-CYLINDER OIL-ENGINE OF RECENT DESIGN
These Are Two Views of the 165 x 220-mm. (6.50 x 8.66-in.) Engine. This Engine Has One Camshaft, with All the Ports on One Side, Whereas Some of the Older Engines Have Two Camshafts with the Exhaust and Inlet Ports on Opposite Sides

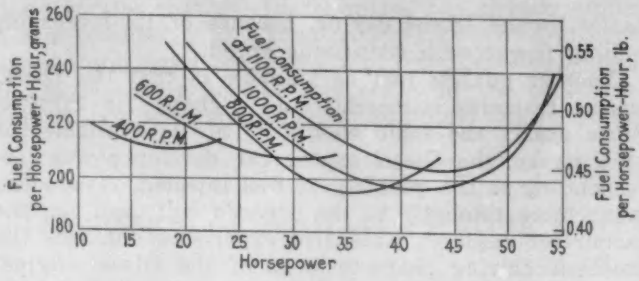

FIG. 10—FUEL CONSUMPTION OF DIESEL ENGINE

These Curves Are the Results of Tests on the 115 x 180-mm. (4.53 x 7.09-in.) Engine. No Correction Has Been Made in This or Other Figures for the Metric Horsepower Given. The Metric Horsepower Is Approximately 1.4 Per Cent Less Than 1 Hp. in English Units

the connecting-rod bolts can be loosened so that the pistons can be taken out from above, after removing the cylinder-heads. The starting motor and generator, as shown in the illustration, are built outside the casing. The engine can be modified also for starting with compressed air.

Other models with greater power, 50 and 100 hp. per cylinder at 700 r.p.m., are under construction, but no details of these are now available.

Exhaustive experiments on the test block have given a rather clear idea of the suitability of engines of this type for car driving, and of their efficiency. Results of fuel measurement at different speeds on the 115 x 180-mm. (4.53 x 7.09-in.) size, with injection through two lateral nozzles, are shown in Fig. 10. These tests were made with a fuel having a rather low heat value of 9930 calories[2]. The specific fuel-consumption, at all speeds used, ranges between 200 and 215 grams (0.44-0.47 lb.) per hp-hr., this being lower than the best values for gasoline engines. Compared with carbureter engines, the fuel consumption is very low over a long range of partial load, a fact that will be found particularly favorable for car propulsion where very low and medium loads are frequent.

Ignition Timing Affects Fuel Economy

The influence of ignition position on the fuel consumption at constant speed is shown in Fig. 11. These tests were made on the 120 x 180-mm. (4.72 x 7.09-in.) engine, with single spray-nozzles, at a constant speed of 1000 r.p.m. One curve relates to normal adjustment of the ignition for 1000 r.p.m. The ignition point of the early-ignition curve corresponds to a normal adjustment for 1400 r.p.m. while the late-ignition curve refers to a 500-r.p.m. adjustment. These adjustments are made to give the normal combustion pressure of 42 atmospheres for the respective speeds. If the early ignition is used at 1000 r.p.m., higher combustion pressures of about 52 atmospheres result; and the retarded ignition, at the same speed, results in lower combustion pressures of about 30 atmospheres. The effect of these changes on fuel consumption is shown in Fig. 11, which demonstrates clearly the desirability of adjusting the ignition for different speeds. This results from the practically constant lag between the beginning of the stroke of the pump plunger and the beginning of injection, with the gradually reduced time available for combustion as the speed is increased.

[2] The approximate equivalent of 9930 calories per kg. is 17870 B.t.u. per lb.

The fuel used for the engine is a high-grade gas-oil, a pure distillate, free from crude-oil residues or the like. Among other suitable fuels are certain low-viscosity crude-oils, lignite tar-oil and shale oil. When the engine is used for driving vehicles, especially in large cities, a very light gas-oil having a boiling point not over 320 deg. cent. (608 fahr.) is considered preferable, to prevent objectionable odor from prolonged idling of the cold engine, or from improper adjustment of the injector or the fuel pumps.

Owing to the high thermal efficiency, the volume of heat carried off by the cooling water is somewhat lower than in the carbureter engine. This property of the Diesel engine permits the use of a radiator smaller than is usual. Oil consumption is just as low as that of good carbureter engines, and the quality of the lubricating oil required is the same.

The Torque Rises as the Speed Falls

What is of especially great importance for practical vehicle operation, particularly in comparison with carbureter engines, is the curves shown in Fig. 12, obtained with the 115 x 180-mm. (4.53 x 7.09-in.) engine with single spray-nozzles. All the tests represented on one curve were made with constant throttle and ignition setting while the engine was run at varying speed by changing the load. The torque curves thus obtained give an idea as to the pulling power of the car with variable running resistance. As can be seen from the curves, the torque increases about 10 per cent while the speed drops about 20 per cent, without changing the admission lever. Hence, temporary extra resistances frequently can be overcome without manipulation, and shifting into a lower gear often can be avoided or at least delayed.

Application of the four-cylinder engine up to the present has been mainly on 5-ton trucks operated generally with a 5-ton trailer. The installation of the engine in the car, seen in Fig. 6, is the same as in a carbureter engine on the same frame. Control of admission through the fuel pump is accomplished by a hand lever on the steering wheel and by pedal, just as

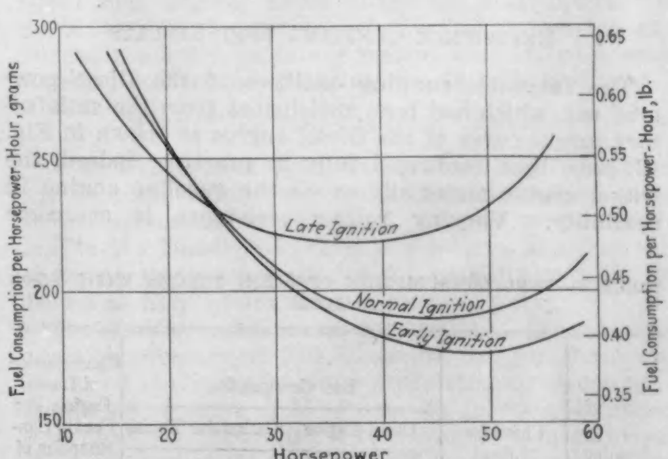

FIG. 11—EFFECT OF THE IGNITION TIMING ON FUEL CONSUMPTION

These Tests Were Made at 1000 R.P.M., with Varying Fuel Admission To Correspond to the Changed Torque Settings. The Curve for Early Ignition Represents a Setting Suitable for 1400 R.P.M. and the Late Ignition Setting Is Suitable for 500 R.P.M.

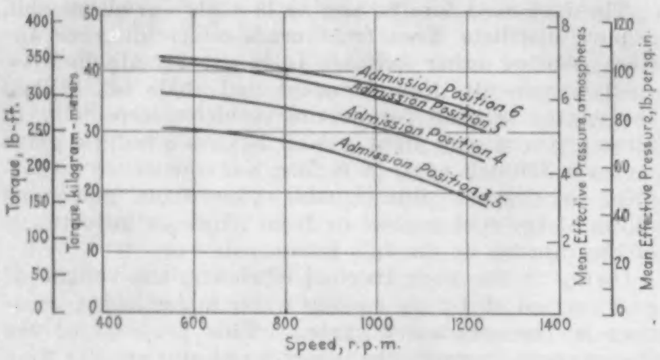

FIG. 12—VARIATION OF TORQUE WITH CONSTANT FUEL INJECTION AT DIFFERENT SPEEDS
Each of the Curves was made With No Adjustment of the Setting for Quantity or Time of Oil Admission. Each Curve Corresponds to One Setting of the Admission or Throttle Lever

with the throttle lever of a carbureter engine. Transmission of motion from the steering column *R* to the pump control shaft is through the double-armed lever *S* and the connecting-rods *T* and *U*. The pedal actuates lever *S* through the double-armed lever *V* and the yielding connecting-rod *W*. The ignition timing is controlled at the steering wheel in the usual manner. Fig. 6 also shows the shaft *X* for cutting out the different cylinders, with its drive *Y*. Compression relief for starting is controlled through drive *Z*. The starting itself is done the same as in the carbureter type of engine, either by a starting motor or by hand.

Confirmation of the fuel economy found by experiment on the test stand was secured under operating conditions by comparative tests with carbureter engines of the same power installed in cars of the same type. In Table 1 are given the results found by a certain official department operating similar trucks with both carbureter and Diesel engines. According to these figures, the fuel consumption of the Diesel engine is 64 per cent of the consumption of a gasoline engine, in round numbers. The saving in running expenses is considerably higher than this indicates, depending also on the relative prices of the fuels.

EXPERIENCE CONFIRMS TEST RESULTS

The favorable running qualities of the Diesel-powered car, which had been anticipated from the satisfactory torque curve of the Diesel engine as shown in Fig. 12, have been confirmed fully in practice; indeed, the Diesel engine materially excels the gasoline engine in flexibility. Varying rolling resistance is overcome easily by the Diesel engine, because of its increasing pulling power with decreasing speed.

TABLE 1—FUEL CONSUMPTION OF 5-TON TRUCKS WITH 5-TON TRAILERS

Loading	Character of Road	Fuel Consumption				Consumption of Diesel Engine, Per Cent of Consumption of Carbureter Engine
		Diesel Engine		Carbureter Engine		
		Kg. per 100 Km.	Lb. per Mile	Kg. per 100 Km.	Lb. per Mile	
Full	Mountainous	50	1.77	80	2.84	62.5
Full	Level	35	1.24	55	1.95	63.5
Empty	Mountainous	40	1.42	65	2.31	62.0
Empty	Level	30	1.06	45	1.60	66.5

Another quality just as valuable is that the Diesel engine responds immediately to a change in throttle. Since nearly the same weight of air is available for each stroke, the Diesel engine can develop power corresponding to the quantity of fuel injected, responding much more promptly to the driver's will than can the carbureter engine. Extensive experience confirms the excellent driving characteristics of the Diesel engine, due mainly to the far less need of manipulation, a quality especially valuable when driving through mountainous regions. A test trip over the well-known German trial section, known as the Nürburgring, has shown that the average speed of the Diesel-powered truck was the same as the speeds of two trucks with substantially larger gasoline engines. The advantage of these more powerful trucks on level stretches invariably was more than overcome by the Diesel-engine truck on the hills.

As to reliability of the Diesel engine, experience obtained with about 100 trucks thus far put into actual service with M.A.N. engines indicates that they have met fully the requirements of running and traffic and leaves no doubt that the Diesel engine is the equal of the highly developed carbureter engine in this respect. This is proved by frequent repeat orders. For example, the Hasenbrauerei, Augsburg, is running three 5-ton trucks, the first of which has traveled 45,000 km. (27,962 miles), mostly with a 5-ton trailer, with no extensive overhauling, although it is operated under heavy-duty conditions, making long runs into the foothills of the Alps.

RAIL-CAR AND MARINE APPLICATIONS

In addition to its use for trucks, the same engine, in its six-cylinder form, has been employed frequently for rail-cars and small locomotives; and it has proved its worth under these more severe operating conditions. The strains and stresses of the engine when installed in gear-driven rail-cars and locomotives are extremely severe, compared with truck operation, especially because there is a substantially larger mass to be accelerated or retarded in changing speed. This condition must be met by making the engine larger. With electric transmission, conditions are more favorable. The installation in a rail-car generally is less accessible and makes inspection, observation and care of the engine more difficult.

At the left in Fig. 7 is a six-cylinder engine installed in a rail-car. The same engine is shown in the upper right part of Fig. 7, with transmission and drive wheels. At the lower right of the same figure is a four-cylinder engine and transmission, installed in a small locomotive.

High-speed Diesel engines have found ready introduction everywhere for marine propulsion. Conditions on the water are more favorable than in road haulage, because there are no sudden load requirements. Light Diesel engines are employed on shipboard also for auxiliary service, such as driving a lighting dynamo and an air compressor. The engine has been used also for driving dredges, hoists, elevators and other machinery.

Because of the time limitations in preparing this paper it was necessary to confine illustrations to the products of the M.A.N.; but the experience acquired in the use of such engines, under practical conditions,

demonstrates that the Diesel engine has already gained a firm foothold in this comparatively new field of high-speed light types for non-stationary purposes, so that it has become a serious competitor of the carbureter engine. Its economy in fuel consumption and its ability to utilize cheap heavy oils will cause its introduction wherever the cost of fuel represents a major item in running expense. The cost of manufacture, which still is higher than that of the gasoline engine, will be still further reduced by further constructional development.

Discussion of Annual Meeting Papers by R. J. Broege[3], Dr. William Riehm and O. D. Treiber[4]

At the Diesel-engine session the discussion was general and followed the presentation of the three engine papers. Recent information on the relation between volatilization and ignition was reported; Diesel, Otto, and combination cycles were compared, and the running characteristics of Diesel engines as reported in the papers were confirmed by further experiences.

Methods and control of injection and combustion were discussed from several angles. Different views were expressed on turbulence, their variance being possibly explained by the varying requirements of different methods of combustion.

Economics of the Diesel engine received due consideration, the economical use of the engine depending upon the continuity of service, according to several of the discussers. The ultimate development of Diesel aircraft engines is expected.

CHAIRMAN C. A. NORMAN[5]:—Diesel engines have been regarded with a somewhat uncertain degree of interest by automotive engineers, who have felt that the automotive problem was well solved by the gasoline engine, with the aid of anti-detonants and gasoline produced by cracking. However, it must not be forgotten that both cracking and anti-detonants cost something; by the time you are through treating the available fuel so that the gasoline or carbureting engine can burn it the cost is considerable. Assuming the life of a truck to be 5 years, the added cost due to using cracked gasoline, or gasoline containing anti-detonants, must average something like $500 per truck.

Sometime ago I attended a session of the American Railway Fuel Association where the Diesel engine was discussed. The majority of those in attendance were operators. They did not talk about fuel economy, although they saved about two-thirds of the fuel costs as compared to the oil-burning steam-locomotive. What interested the locomotive engineer was the ease with which the Diesel locomotive was handled.

We may discover pleasant things like that about the Diesel engine in trucks and tractors, in addition to the saving in fuel cost. Its high pulling power at low speed on grades has already been discovered. The engine is needed for aeronautical purposes on account of economy and safety. It is now incumbent upon American engineers to develop this engine as only American engineers can, making it suitable for manufacture at low cost and as fool-proof as is possible.

J. E. WILD[6]:—Our experience in regard to cooling a Diesel engine in a truck confirms that reported by Dr. Riehm and our fuel consumption agrees closely. The truck with which our tests are being made has a total weight of 11,500 lb. and a load capacity of 5 tons. The engine has 4½-in. bore and 7-in. stroke, and the fuel-oil consumption in New York City traffic is 1 gal. for each 10 miles. During a recent test-drive of 1200 miles with a load of 2 tons, the average mileage was 11.6 per gal. of fuel. From half load to full load the fuel consumption is almost constant, averaging 0.45 lb. per b.hp-hr. Compared with a gasoline engine, the fuel economy of a Diesel engine is more favorable at part load.

No doubt the open nozzle is entirely satisfactory; the spring-loaded injector also is entirely satisfactory and gives the designer more freedom in the arrangement of the engine. The length of the injection pipe does not matter with the Bosch-Arco system, as surging of fuel in the pipes is not encountered with the spring-loaded valve. Since our engine has been developed past the experimental stage it is very reliable and more flexible than any gasoline engine of equal size.

Adjustment of injection timing according to speed is advisable with engines in which the fuel is injected directly into the combustion-chamber, coming at once into contact with the entire volume of air. At high speed such engines knock unless the fuel injection is made later in the stroke. If the fuel is injected and burned gradually, as in our system, there is no detonation and no need for changing the time of injection.

MEAN EFFECTIVE PRESSURE COMPARED

J. H. GEISSE[7]:—At first Mr. Treiber's paper gave me the impression that he contends that the ratio of mean effective pressure to maximum pressure is necessarily less in the Diesel cycle than in the Otto, and that this accounts, to some extent, for our inability to build the Diesel as light as the Otto engine.

Mr. Treiber made some calculations, using a compression pressure of 350 lb. per sq. in. for the Diesel cycle. I have made some calculations, assuming a maximum pressure of 550 lb. per sq. in. for both cycles. For the Otto cycle, with 5 to 1 compression ratio and Ricardo's exponents for compression and expansion, the mean effective pressure figures out to be 123 lb. per sq. in.

For my calculation of the Diesel card I used a compression pressure of 550 lb. per sq. in., instead of 350 lb., and constant-pressure combustion. To make the

[3] M.S.A.E.—Chief engineer, Buda Co., Harvey, Ill. See THE JOURNAL, February, 1928, p. 177.

[4] M.S.A.E.—President and chief engineer, Treiber Diesel Engine Corporation, Camden, N. J. See THE JOURNAL, February, 1928, p. 183.

[5] M.S.A.E.—Professor of machine design, Ohio State University, Columbus, O.

[6] M.S.A.E.—Vice-president, Robert Bosch Magneto Co., Inc., Long Island City, N. Y.

[7] M.S.A.E.—Chief engineer, aeronautical engine laboratory, Naval Aircraft Factory, Navy Yard, Philadelphia.

Otto and Diesel cards directly comparable I made the difference in energy content of the gases between the beginning and the end of combustion the same for both cycles. Since the maximum pressure for the Otto cycle was held at 550 lb. per sq. in., this method takes care of jacket loss, losses from dissociation and the like, assuming that they are the same for both cycles. The Diesel card thus figured gave a mean effective pressure of 145 lb. per sq. in., a little higher than the Otto.

The cycle on which Mr. Treiber based his figures was a combination of Otto and Diesel. That this cycle gave him a lower ratio of mean effective to maximum pressure may be accounted for by the fact that an 8 to 1 compression-ratio Otto engine gives a lower ratio of pressures than does the 5 to 1 compression ratio.

Mr. Treiber mentioned time lag of ignition relative to vaporization. My impression is that, in a number of tests, the time lag of ignition seems to have borne a closer relation to the turbulence in the cylinder than to the fineness of the spray.

I am a Diesel advocate, but we are now using air-cooled engines with a fuel consumption of only 0.44 lb. per b.hp-hr., which gives the Diesel engineer a new Otto-cycle figure to consider.

H. A. HUEBOTTER[8]:—A year ago I computed the characteristics of cycles varying from the true constant-pressure cycle to the true constant-volume cycle. I found that the greater the amount of fuel burned at constant volume is, the higher is the thermal efficiency, as one would expect, since more work is derived from the expansion of the gas. Under this kind of analysis the indicated mean effective pressure is proportional to the indicated thermal efficiency. My conclusion was that it does not pay to burn much more than one-fourth of the fuel at constant volume. Although the mean effective pressure and the thermal efficiency increase as the constant-volume cycle is approached, the detrimental effects on the engine from the high temperatures and pressures more than offset the small gain in power and efficiency. The best practicable working cycle for the mixed Diesel engine is found with 350-lb. compression pressure and a rise to about 700-lb. combustion pressure at constant volume, the rest of the fuel being burned at constant pressure.

THE VALUE OF TURBULENCE

L. F. BURGER[9]:—In my opinion turbulence has little effect in a Diesel engine. At the time of injection any turbulence should have become dormant. I would like to have a little light on that subject from someone who has had experience.

MR. GEISSE:—There are many reports which show that turbulence improves the performance considerably.

CHAIRMAN NORMAN:—It is a peculiar thing that, on the one hand, R. Hildebrand, of the Fulton Iron Works, has contended that turbulence may be even harmful and, on the other hand, the Swedish engineer Hesselman, a great authority on the subject, has developed special designs to induce turbulence. I know of one Diesel engine in the Country which was improved by turbulence. It shows that there are many paths to salvation.

H. M. JACKLIN[10]:—Some 3 years ago I was associated with a builder of low-compression two-cycle injection oil-engines. Some experiments we performed on the effects of turbulence may be interesting. The tests were made on a single-cylinder 75-hp. engine. Several arbitrary proportions of the combustion-chamber were decided upon, contributing to what we termed stages of turbulence.

At the start the engine delivered 1 hp-hr. for 0.65 lb. of fuel; our first stage of turbulence brought the fuel consumption down to 0.52 lb., and we had to retard the injection a little; our next stage brought the consumption down to between 0.49 and 0.50 lb.; and our last stage reduced the fuel consumption to between 0.44 and 0.46 lb. per hp-hr. On the last stage it was necessary to retard the injection considerably because of apparent preignition. The turbulence gave some whirling effect to break up the jets transversely, as well as against their flow. We intended to try one more stage, but the engine was wrecked because of an error in assembling.

The indications were that a consumption of 0.43 lb. per hp-hr. could be obtained, which would have been an excellent figure for an engine with a compression of less than 200 lb. Turbulence seems to be as important for the injection engine as for the carbureting engine, and it has considerable effect on time lag.

GAS-OIL NOT THE ULTIMATE FUEL

DR. RAYMOND HASKELL[11].—Mr. Treiber mentioned that the ideal condition necessary to obtain high speed was by means of injecting completely vaporized fuel into the Diesel engine. This, however, is not practical. The preferred Diesel fuel at present is a gas-oil, which vaporizes at 500 to 650 deg. fahr. at atmospheric pressure. Vaporizing at a pressure high enough to force it into the engine in vapor form would necessitate bringing it above the cracking temperature and cause formation of carbon or tar. Even though the fuel is vaporized completely, under low pressure, it will liquefy again under the pressure required to get it into the engine and will enter the engine as a liquid the same as before; although it may be a very easily atomized liquid and be very good for the purpose.

However, I believe the Diesel engineer must sooner or later find some other fuel than gas-oil, as that can be cracked very easily into gasoline with a high percentage of yield. This means that the price ultimately will be high, depending on the price of gasoline. Therefore, he must economically use a fuel with at least a portion of residual oil. This residual oil in turn will not vaporize at all and will not operate in a system which vaporizes completely, as it would leave tars and carbon.

CHAIRMAN NORMAN:—The most recent researches on time lag, by Dr. F. Sass[12], show that it is unnecessary to gasify the fuel before it will ignite.

MR. WILD:—As Professor Norman says, there are many roads to Rome. In the Bosch-Arco system we do not want much turbulence. We use an injection nozzle that gives a fairly coarse spray, and too much turbulence would destroy the flexibility desired. We inject the oil in a comparatively solid spray into a receptacle which afterward is fully turbulated by an out-rushing flow of air from an auxiliary air-chamber.

[8] M.S.A.E.—Chief engineer, Butler Mfg. Co., Indianapolis.

[9] M.S.A.E.—Chief engineer, stationary engines, International Harvester Co., Chicago.

[10] M.S.A.E.—Associate professor of automotive engineering, Purdue University, West Lafayette, Ind.

[11] Industrial engineer, The Texas Co., New York City.

[12] See *Mechanical Engineering*, November, 1927, p. 1232 and *Zeitschrift des Vereines Deutscher Ingenieure*, Sept. 10, 1927, p. 1287.

Steps in the Development of an Engine

EDWARD RATHBUN[13]:—We obtain turbulence by a restriction, or neck, between the combustion-chamber proper and the space swept by the piston. Recently we have been working on an 8¼ x 12 in. engine, which is a small size for us, running at 450 r.p.m.

To determine the effect of a change in the area of the passage between the combustion space and the piston space, this area was reduced 20 per cent. The maximum combustion pressure jumped from 550 to 650 lb. per sq. in., and it was necessary to retard the point of injection to bring the pressure back to the lower figure. This seems to indicate a means for controlling the rate of combustion for high speeds.

Our engine was developed from the Price single-cylinder engine, and our first multiple-cylinder engines, which were six-cylinder marine engines for direct connection, were made with the same compression of 200 lb. They could not be started cold without a hot-wire igniter. After a few turns they would run and restart without the igniter, even after standing some time. The multiple-cylinder stationary engines, however, we found would not run below three-quarters load without missing. We overcame this condition by throttling the exhaust, thus increasing the temperatures.

On a 300-hp. engine, for running light, it was necessary to reduce the exhaust outlet to about the area of a 1-in. pipe. This reduction must be made automatically, and the hook-up to the governor was not simple. Attempting to avoid this, we increased the compression to 250 lb. and found that a three-cylinder engine would run at about half load without throttling the exhaust. With 300 lb. compression about one-quarter load could be handled without missing, and 350 lb. was found to be about the minimum compression for commercial operation.

For injection on multiple-cylinder engines we use a single pump, a distributor and open nozzles.

Advantages of Pre-Combustion

CHARLES B. JAHNKE[14]:—Experience has proved that no one type of Diesel engine is best. It is a machine of delicate combinations, and that fact has given the Diesel engineer more trouble than any other one thing. The present gasoline engine has been designed on one principle, possibly, more than the Diesel can ever be; yet the last few years, during which turbulence has been given a good deal of attention, have seen some radical improvement in the gasoline engine. It has been made to approach the Diesel engine in performance.

Each manufacturer of Diesel engines has specialized upon certain combinations; it has been my part to follow the two-cycle principle, largely for its simplicity in detail, and the pre-combustion scheme of burning.

Turbulence plays a very vital part in pre-combustion. We have found that the same proportions of combustion details seem to be practicable in both small and large bores, ranging from 4½ to 16-in. diameter; combustion follows a definite law. Pre-combustion has the advantage of requiring only a relatively low-pressure injection, which simplifies the mechanism and makes the problem easier.

With pre-combustion, time lag is much less important than in the open-combustion type of engine with direct injection, and I believe that pre-combustion offers possibilities for high-speed work because the mixture is prepared and begins to burn in the antechamber before entering the main combustion space over the piston.

The Diesel engine is really in its infancy. We have just substituted solid injection for air injection, and that has opened up many new lines of development. It has been a common fault of European designers to use complex designs in striving for the ultimate in efficiency. That has closed our eyes to many of the advantages that American engineers will recognize, and I look for great improvement and development of the Diesel engine in this Country.

It has been our experience that the maximum torque in a Diesel engine can readily be maintained down to 25 per cent of its normal running speed. At one-third speed the fuel consumption is about 5 per cent higher than normal at corresponding torque. Our experience has indicated that 350-lb. compression, while sufficient for larger bores, is not high enough for small bores.

Diesel Cycle Best for Large Sizes

H. L. HORNING[15]:—We believe that the Diesel engine has a tremendous field and we are working hard to get into that field. However, the physical and natural limitations that face the designer when he comes to produce a 30 or 40-hp. multiple-cylinder Diesel for automotive purposes are tremendous. From the opinion of unbiased men throughout Germany I was much surprised to find that, after years of effort to produce an engine for trucks and industrial purposes, the Germans began to forget this necessity for a small Diesel engine when they were blessed with gasoline at a little less than 30 cents per gal.

Diesel engines are very economical and very reliable in the large sizes. They require complications not needed for gasoline engines, but that is not the point; the point is that in a great many cases utility and adaptability are much more important for the service than mere fuel economy. A contractor would gladly double his fuel and oil consumption to move 2 or 3 cu. yd. more per day.

In most applications of industrial engines fuel consumption is not an important figure. On a shovel that works in a sky-scraper excavation for a month and then crawls out and waits for the next job, so that it is shoveling only about 100 days during the whole year, the contractor cannot afford a Diesel engine because it is not doing enough work. But in a case where a shovel is to make a Culebra cut, or move a mountain, as they are doing in Seattle, where it works day and night for 300 days per year, a big Diesel engine is needed. There is a chance to utilize the economies of the Diesel engine and the expensive equipment by a tremendous amount of steady work.

So with a shovel, for instance, there is an economic line below which a Diesel engine is not economical. Probably it should not be used on a shovel with a bucket smaller than 1 or 1¼ cu. yd. or on one that does not work more than 175 or 150 days a year. So in this, as in other matters of business, the engineer must keep an open mind and preserve a good perspective.

Economics determines where a Diesel engine should be used. For economic reasons we are requested by many manufacturers not to give them a gasoline engine

[13] Vice-president, Rathbun-Jones Engineering Co., Toledo, O.

[14] M.S.A.E.—Director of engineering, Fairbanks, Morse & Co., Beloit, Wis.

[15] M.S.A.E.—President, general manager, Waukesha Motor Co., Waukesha, Wis.

that will last longer than 5 years, because the tool it runs will be worn out long before 5 years and the outfit may be obsolete in 2 years, so rapid is the progress in the design and utility of power machinery. To get the job done is more important in many projects than the cost of fuel.

CHAIRMAN NORMAN:—When one of the important men in the automotive industry came back from Europe he said, "Well, the engineers over there don't make any money, but they are having a darned good time." I feel that American engineers ought to rise up now and have a good time with the Diesel engine, which is a most fascinating thing. If they have a chance they will produce astonishing results. Those who take a negative attitude on the Diesel engine may regret it later.

DIESEL ENGINES FOR AIRCRAFT

L. M. WOOLSON[16]:—The Diesel engine is extremely attractive for aircraft from two viewpoints; first, fire hazard and, second, increasing the cruising range of aircraft; in fact, after the phenomenal long-distance records of 1927, I am almost ready to prophesy that there will be no great advance in that direction until we have Diesel aircraft-engines, which promise to reduce the fuel consumption greatly.

EDWARD P. WARNER[17]:—It has occasionally been suggested that the Government departments, especially the Navy, have been indifferent to the development of Diesel powerplants. I repudiate any such suggestion. We are fully appreciative of the great theoretical possibilities of the Diesel, especially on long flights of airplanes or airships where fuel consumption becomes of greater relative importance than the weight of the bare engine. I am confident that the problems of the heavy-oil compression-ignition engine for aerial service will be solved, and what we hear at this session is most encouraging as indicating that we are on the road; but we are unable to feel that the solution, in the form of an aeronautic engine ready for operation, is immediately at hand. We shall do all that we can, consistent with proper attention to those standard types of gasoline engines on which our major dependence must certainly be placed for a number of years yet, to speed its coming. When it is here it will be more than welcome, and I hope that it will ultimately bring not only decreased fuel consumption and reduced fire hazards, but increased reliability and life as well, in its train.

HARTE COOKE[18]:—The smallest Diesel engine we build is about 200 hp., and all our engines use air injection. We have equipped with one of these engines a 94-ton main-line rail-car which seats about 50 people and has baggage space. It can be operated from either end, and the power is sufficient to enable it to adhere to the regular steam-railroad schedule. This car will run 3 miles on 1 gal. of fuel oil.

A 76-ton switching locomotive is equipped with one of our 300-hp. engines and handles freight cars in small yards. Although busy all day, it does not cover many miles. It consumes 20 gal. of fuel oil per day and 5 gal. of lubricating oil per week. Another locomotive under construction for main-line passenger service is rated at 900 hp. at 300 r.p.m. All these units are driven by electric motors on the axles and equipped with generators direct-connected to the engines.

ADVANTAGES IN RAILROAD SERVICE

S. T. DODD[19]:—There are a number of reasons for the present widespread interest in the use of the Diesel engine for transportation service.

The first of these reasons is its economy. A striking illustration of this is found in the results of a comparative test made on one of our 600-hp. Diesel locomotives that is in service on a Western railroad. The Diesel-engined locomotive was operated for 24 hr. in switching service and records were kept of the tonnage moved and the fuel consumed. The next day an oil-burning consolidation-type steam locomotive was put on the same service in its place. Both locomotives used fuel oil of the same cost and practically the same character. The Diesel locomotive handled 48,000 ton-miles in the day's service and consumed 180 gal. of fuel. The steam locomotive handled 37,000 ton-miles in the day's service and consumed 1370 gal. of fuel. Reduced to a ton-mile basis, the Diesel locomotive handled 267 ton-miles, while the steam locomotive handled 27 ton-miles per gal. of fuel.

The second feature of advantage in the Diesel locomotive is its ease of control. Too much of the time and attention of the steam engineer is required by the mechanical features of the locomotive; such as steam gage, water level, throttle, cut-off, and reverse gear. These demand attention at the expense of purely traffic problems. The well-known fact that an electric locomotive can handle more switching movements than a steam locomotive in a given time is due to the fact that the operator can devote his whole attention to traffic, because the movement of control and reverse handles is largely subconscious. The same condition applies to the Diesel locomotive; after starting the engine, the control problems are reduced to the adjustment of the throttle to give the power and speed required.

A third advantageous feature of the Diesel locomotive is its ability for continuous service. Many of our Diesel-electric locomotives are working from 16 to 24 hr. per day for 6 days per week, with a few hours devoted to overhauling and adjustment on Sunday. No steam locomotive, with its demands for engine and boiler maintenance, can compare with this for continuity of service.

The real reason why the subject of the present paper is intensely interesting is that we can see a real field for a light, high-speed Diesel engine. There is, of course, a field for the present type of Diesel locomotive for slow-speed service where a locomotive of heavy weight and a not excessive horsepower is required. The conventional Diesel-engined locomotive, including engine, transmission, auxiliary apparatus, radiator, fuel supply, and the like, weighs from 300 to 400 lb. per engine hp. A steam locomotive, including its tender, fuel and water, weighs from 200 to 300 lb. per hp. delivered at the driving wheel. To compete with a modern steam locomotive of 1500 to 2000 hp., we must make a general reduction in the weight of all parts of the Diesel-engined locomotive, and primarily we require a light, high-speed Diesel engine.

ECONOMY OF DIESEL-ENGINED LOCOMOTIVES

HERMANN LEMP[20]:—It now is possible to produce Diesel engines weighing from 40 to 60 lb. per hp. The

[16] M.S.A.E.—Aeronautical and research engineer, Packard Motor Car Co., Detroit.

[17] M.S.A.E.—Assistant Secretary of the Navy for aeronautics, Navy Department, City of Washington.

[18] M.S.A.E.—Mechanical engineer, McIntosh & Seymour Corporation, Auburn, N. Y.

[19] General Electric Co., Schenectady, N. Y.

[20] Consulting engineer, Ingersoll, Rand Co., New York City.

transmission, accessories and other parts of the locomotives bring the weight up to about 250 lb. per hp. The steam locomotive, including its tender with fuel and water, weighs much more than 150 lb. per hp.

Another example of oil-electric economy is given by the high-speed locomotive that recently drew four coaches between Hornell, N. Y., and Meadville, Pa., about 184 miles, over two sections of railroad, with a consumption of only $7.70 worth of fuel and lubricating oil, 1 cent per mile per coach. The maximum and average speeds were about 56 and 37.7 m.p.h., respectively. It was operated by two steam engineers, one for each section, and neither had ever seen the locomotive before except to have about 4 min. instruction in the operation of the control handles.

R. Tom Sawyer[21]:—If a railroad needs equipment to substitute on the run of a locomotive, a gasoline engine should be chosen; but, if the engine is to be used for more hours every day, the Diesel engine will be worthwhile because of its fuel economy.

In the same way, a gasoline engine is suitable for a motor-fuel that runs only 8 hr. per day, but operation with more than one shift of drivers makes an oil engine worthwhile. One reason is that the oil engine is more nearly fool-proof than the gasoline engine.

Research Needed on Combustion Problems

Robertson Matthews[22]:—Statements made in the Research Session and in this Diesel Engine Session prompt the comment that the Fuel Subcommittee of the Research Committee should be encouraged to consider the combustion problems of the high-speed compression-ignition engine. I venture to predict great benefit from such consideration. The Research Session papers dealt with the problem of the final stages of combustion being too rapid. Today the papers are concerned with a problem of the initial stages of combustion being too slow. These extremes suggest that there is probably a common ground for investigation.

One common ground probably is the joint behavior of carbon and water vapor during combustion, for here are two more extremes. Water has been considered as an antiknock substance, but for 125 years it has been known that dry carbon monoxide will not burn. Yet how much do we definitely know today of the reactions between carbon and water vapor?

Although carbon is at least 85 per cent of our liquid fuels, what do we know concerning its combustion? Exposed flames are not permitted around a mill where carbon is being ground, but a stick of compressed carbon in an open arc-lamp will burn at an imperceptibly slower rate at a temperature of over 6000 deg. fahr.

In the time lag of ignition at high speed we probably have, besides intimacy of contact, the problem of the *dwell* of intimacy of contact. I can conceive a multitude of small burning spheres, like miniature candles as the piston approaches dead-center, being extinguished by the sudden reduction in intimacy of contact as the piston recedes. Sustaining combustion after its initiation may be a serious problem. We dope fuel to slow up combustion; perhaps it requires dope to encourage inflammation. However, more knowledge of the fundamentals of combustion of carbon under engine conditions is essential, for both the carbureter engine and the high-speed compression-ignition engine.

Debatable Questions in Diesel Design

P. H. Schweitzer[23]:—In laying out a new steam turbine, electric motor or even gasoline engine, there is an established practice to follow. In designing a new Diesel engine, the engineer must take sides on a number of questions on which the best engineering minds disagree.

I agree with Mr. Treiber's choice of airless injection and open combustion-chamber. Because of the fewer moving parts resulting in a simpler design I prefer the two-stroke cycle, but it must be admitted that neither the art of scavenging nor that of heat dissipation is sufficiently advanced to allow building a 3000-hp. two-cycle engine to run at 700 r.p.m. on a basis of safely established practice.

In a solid-injection engine, the most debatable question is between constant-pressure injection and the jerk pump. Among the troubles with the direct pump system are after-dripping; misses caused by air bubbles; secondary discharges from pressure waves; destructive jerks of the pump-plunger; water-hammer action in the fuel line; varying injection-lag, due to both the compressibility of the liquid and "breathing" of the pipe; and falling off of the injection pressure and quality of atomization at low speed.

While the constant-pressure system is free from these troubles, it has disadvantages of its own: (*a*) To be effective, the injection control must be in the spray nozzle, and a mechanically operated spray-nozzle is complicated; (*b*) with fuel continually under pressure in the line, even a slight leakage in the injection nozzle will cause dripping that is hard to detect, and the dripped fuel may cause undesirable explosion pressure; (*c*) metering of minute quantities of fuel by keeping the valve open for a definite length of time is not positive enough, and the distribution becomes uneven if some nozzle orifices are widened by erosion or clogged.

As a rule, high fuel-economy does not accompany high mean indicated pressure. In an engine with 14 to 1 compression ratio, 185 lb. mean indicated pressure can be secured on a fuel consumption as low as 0.25 lb. per hp-hr., but both cannot be obtained together, according to the theory developed by George A. Goodenough and John B. Baker[24]. The lowest theoretical fuel consumption with this mean indicated pressure is about 0.41 lb. per hp-hr. With 0.25-lb. fuel consumption, the theoretically highest mean indicated pressure is 104 lb. If the excess air is cut down to below about 50 per cent, too much efficiency is sacrificed. This is confirmed by experiments showing the highest thermal efficiency at one-half and one-quarter loads.

Less objectionable ways for increasing the mean indicated pressure are sharp-top combustion and supercharging. Not long ago constant-pressure combustion was considered ideal, but we have learned that both good fuel economy and high output demand sharp-top or constant volume combustion.

On the other hand, low engine weight demands a high ratio of mean effective pressure to maximum pressure, which means constant-pressure combustion. The mixed

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[21] M.S.A.E.—Engineer, motor department, General Electric Co., Erie, Pa.

[22] M.S.A.E.—Research engineer, mechanical engineering, Detroit Edison Co., Detroit.

[23] M.S.A.E.—Associate professor of engineering research, Pennsylvania State College, State College, Pa.

[24] See University of Illinois Bulletin No. 160.

cycle with constant-volume combustion to a pressure of 700 lb. per sq. in. seems a desirable compromise, but it is a problem to control the combustion so as to secure this.

Mr. Treiber deserves great credit for the achievement represented by indicator cards with mean indicated pressures of 160 lb. per sq. in. and also for the 3000-hp. engine under construction. The lightest engines of this size have weighed 60 to 70 lb. per hp., and this engine weighs about 20 lb. per hp. If it will withstand the test it represents a very distinct advance in Diesel engineering.

Hugo K. Moren[38]:—In an engine with twin parallel 2¾-in. diameter pistons and 7-in. stroke, I have observed an increase in indicated mean effective pressure from about 125 lb. per sq. in. at 1200 r.p m. to about 135 lb. per sq. in. at 1600 r.p.m., a 4 to 5-deg. advance in timing being required at the higher speed.

At speeds higher than 1600 r.p.m. it is very difficult to secure high mechanical efficiency in a Diesel engine, largely because of the friction of rings of the number and tension required.

Experience confirms my belief in the jerk pump, and it can be made to operate a remote automatic valve with even more precision than cam actuation. The automatic valve developed by the National Advisory Committee for Aeronautics is particularly light and simple.

The spray holes for a cylinder having a bore of even only 3 in. need not be smaller than 1/64 in. A short stroke is advisable for high speed.

[38] M.S.A.E.—In charge of gasoline and high-speed Diesel-engine development, American Machine & Foundry Co., Brooklyn, N. Y.

British Commercial Aviation

Regular commercial aviation began in Great Britain in 1919 with two companies, operating between London and Brussels, and London and Paris. Because these companies were not subsidized, they were unable to compete with the lower rates of subsidized French companies. A temporary scheme of British subsidy was therefore inaugurated in March, 1921, and continued under various revisions until March, 1924, when the control of British aviation was given to one company, the Imperial Airways, Ltd., which has had a monopoly of British-aided civil air-services ever since.

In the first period, from 1921 to 1924, the British Government granted subsidies to air services amounting to $3,408,900.[1] Since that time the Imperial Airways, Ltd., has received a subsidy of $685,000 a year plus $150,000 for the year ended March 31, 1927, and current sums on the Egypt-India service. The Light Airplane Clubs, of which there are now 10 in Great Britain, also received subsidies. The total subsidy of all these from March, 1921, through March, 1928, amounts to $6,913,000. The cost of other government aids to the development of civil aeronautics during the same period is estimated at $10,214,530.

[1] All British monetary figures have been reduced to dollars at the rate of $5 to the pound sterling for the sake of clarity.

TRAFFIC RESULTS ON REGULAR SERVICES

Year Ended Dec. 31	Passengers Carried	Cargo Carried, Tons
1919 (8 months)	870	30.0
1920	5,799	137.0
1921	5,256	19.4
1922	10,393	214.6
1923	15,552	328.1
1924	13,601	542.8
1925	14,068	550.0
1926	20,367	679.0
Total	85,906	2,500.9

It is interesting to note that in the last annual report of Imperial Airways, Ltd., it is stated that, compared with that company's subsidy of $685,000 in 1927, Germany, including the municipalities, voted aviation subsidies of $6,500,000 and France $3,170,000. The monopoly held by Imperial Airways, Ltd., lasts for 10 years, until 1934. The company's subsidy is repayable when it attains a profit-earning condition.

The accompanying table shows the growth in traffic handled by the Imperial Airways, Ltd., between Great Britain and the Continent. Competing with the French, Dutch, Belgian and other companies, the Imperial Airways, Ltd., carried in 1926 about 61 per cent of the cross-Channel air-passenger traffic, as compared with 51 per cent in 1925.

Of the 4,374 flights scheduled during 1926, 8.5 per cent were cancelled as compared with a cancellation of 18.6 per cent in 1925. The percentage of flights completing the schedule was 92 per cent in Europe and 100 per cent in the Near East. The excellent record as far as accidents are concerned maintains the generally high standard in this regard for most regularly operated air routes. In the entire period 1919-1926, 15 passengers were killed on the regular services. During the last 2 years there have been no accidents whatsoever resulting in death or injury.

The factor of weather, which has been an obstacle to British aviation, may ultimately prove a stimulus to aeronautical research and invention, and in this way prove of benefit to aviation throughout the world. Today, British airport lighting facilities are not ready for fog flying, nor indeed for night flying, and the fulfilment of regular schedules in passenger and freight transportation will, of course, depend upon the solution of these problems. There can be no doubt about the seriousness with which Great Britain is seeking to gain or to retain first place in commerce through the air, as it has done in commerce on the sea.—Bulletin of the Daniel Guggenheim Fund for the Promotion of Aeronautics.

The Control of Airplane Airworthiness

Discussion of E. W. Stedman's[1] and Clarence M. Young's[2] Aeronautic Meeting Papers

HEREWITH is printed the oral and written discussion on both Commander Stedman's paper, Control of Aircraft Design, published in THE JOURNAL for November, 1927, p. 516, and Mr. Young's paper, Technical Problems of the Control of Airplane Airworthiness, published in the same issue of THE JOURNAL, p. 519. Abstracts of the two papers are printed herewith, supplemented with a synopsis of the discussion in this issue.

Control of Aircraft Design

DIFFICULTIES experienced in regard to the engineering features of the control of civil aviation during a period of 7 yr. are summarized by the author in the expectation that they will afford a better exchange of ideas and be productive of data and suggestions from other engineers that will tend to obviate such difficulties.

After giving an outline of the formation of the International Commission for Air Navigation subsequent to the Great War and commenting upon the Canadian Air Board Act of 1919, the author discusses the I. C. A. N. minimum requirements of aircraft and engines for airworthiness which are now being worked to in Canada as closely as possible. He criticizes the apparent unfortunate tendency of aircraft designers purposely to pare their designs down to the lowest figures that will meet the minimum requirements, and suggests improvements in practice in this respect.

The extreme difficulty attendant upon the inspection of aircraft and the certification of used aircraft as to airworthiness is emphasized. The suggestion is then made that regulations must make the minimum requirements for strength and performance sufficiently great to allow for reasonable deterioration of structure and the loss of engine power; but, in the author's belief, the correct remedy undoubtedly is for the designer to accept the principle that he must design his aircraft so that, with reasonable maintenance and life, the strength and performance will never fall below the minimum as laid down or will be greater if the designer thinks the minimum is too low.

The effect of increasing load-factors is discussed as well as the subject of what load factors are desirable, and their proper grading. The author concludes by making an appeal to other engineers for data and suggestions concerning the determination of what recommendations should be made for strength and for performance requirements.

Technical Problems of Airworthiness Control

ACTIVITIES of the Department of Commerce in the regulation of commercial interstate flying under the Air Commerce Act of 1926 are outlined. Airworthiness can be divided, states the author, into three categories: (*a*) strength and arrangement of the structure, (*b*) reliability of the powerplant and accessories, and (*c*) competence of the operating personnel. The trend in development of truly commercial engines, propellers, airplanes and aircraft instruments will require regulations other than have heretofore been applied to military aircraft. Not desiring to be paternalistic, the department is trying to provide methods of regulation which are fair to both government and industry. Many instances of the difficulty of the solution of the problems involved are discussed, such as those relating to load-factors, technical construction, inspection of materials, and maintenance inspection.

The author expresses the belief that the next sessions of the various State Legislatures will settle satisfactorily the problem of State controlled intrastate and Federal controlled interstate flying.

In the discussion, opinions are expressed that Government regulation under the Air Commerce Act of 1926 is being administered properly; and that an insurance inspection differs from a Government inspection in that the former involves dollars, appraisals and present condition of the aircraft, whereas the latter relates solely to safety in flying. Solution of the safety and success of commercial aviation lies, in the opinion of several discussers, solely in the hands of honest manufacturers who will design, not for the minimum requirements, but for the service required.

THE DISCUSSION

CHAIRMAN EDWARD P. WARNER[3]:—Not many years ago no regulation of transportation of any kind of commerce was needed. Individuals who came in contact with such industry as existed, or with the individuals or small groups offering transportation service, could judge for themselves the probable value and safety of that service. But times have changed, the sails of

[1] Wing commander, Royal Canadian Air Force, and chief aeronautical engineer, Department of National Defence, Ottawa, Canada.

[2] Director of aeronautics, Department of Commerce, City of Washington.

[3] M.S.A.E.—Assistant Secretary of the Navy for Aeronautics, Navy Department, City of Washington.

clipper ships have been superseded by machinery hidden in the depths of the vessel and it became apparent that it was too much to expect that the individual should satisfy himself before he went on board that the boiler would not blow up. That was the beginning from which government has gone on to assume increasing responsibility for the lives of its citizens and the safety of their property when they travel by land or sea, and now by air.

It has sometimes been suggested that the regulation of aerial transportation is temporary, that in time aircraft will be safe as a matter of course, and that air transport and airplane manufacture will regulate themselves. It seems to me that this is somewhat unlikely, reasoning by analogy from the experience in another industry with which the membership of this Society as a whole is intimately concerned. In the early days of the automotive industry no one worried about safety. Only in the last 2 or 3 years, after the industry had been developed to a high point and vehicles had come to number tens of millions on the roads, has government come to recognize its responsibility to supervise the individual vehicle. Brakes, lights, signalling devices and other auxiliary equipment must now be in satisfactory condition for the vehicle to be allowed to remain upon the highway. If that analogy holds good, certainly the individual airplane will remain the subject of regulation for an indefinite period.

The United States was comparatively slow to begin the issuance of certificates of airworthiness upon a National scale. I assume that those responsible for the making of plans for the inauguration of processes of control in the United States, after the Air Commerce Act had been passed, gathered whatever information they could from a careful study of the experiences of other countries. Our neighbors on the other side of the Great Lakes showed us, before we had undertaken any regulation of civil flying on this side, a completed draft of regulations already in successful use and employed for several years in encouraging and stimulating the development of safe commercial flying in Canada.

Fears of Regulation Have Not Materialized

It is rather difficult to recall, a year and a half after the Air Commerce Act was enacted, the vague fears of Government regulations that were expressed previous to its enactment. However serious those fears may have been in some quarters, I think that nearly everybody is well satisfied that they did not materialize. Discussion on the advisability of regulation is out of date. Experience has shown that the law is being administered, and it is confidently hoped that it will always continue to be administered, in a reasonable way, with the sole object of ensuring the public safety and thereby giving reason for increased public confidence in aviation. The satisfaction with the form of the Air Commerce Act that is now generally evident and the confidence that is felt in its workings are largely a satisfaction with and a confidence in the personnel under whose direction it is being administered.

Everyone here must have been struck, as I was, with the several points at which there is apparent parallelism between the problems and the difficulties already experienced in the American and the Canadian operations. Points particularly in Commander Stedman's paper that impressed me are:

(1) The importance of deterioration in service and of some means of estimating it, a factor which obviously will vary with the type of construction
(2) The suggestion that airplanes should be incapable of being broken in the air, about which some difference of opinion may find expression here
(3) Although the airworthiness requirements, as listed by the representatives of the Department of Commerce, were in large part aerodynamics, Commander Stedman made no mention of the procedure in force in Canada for satisfying the authorities upon the stability and control of aircraft. The relative importance of aerodynamics and of structural factors in requirements to be enforced by the Government is a point on which operators and manufacturers must have strong opinions

Considerations of Insurance Inspections

Archibald Black[4]:—Commander Stedman suggests the possibility of the inspection work being taken over entirely by private organizations such as insurance companies. That policy would necessitate placing a heavy charge for inspections upon the applicant and for the insurance. At present the policy is for the insurance companies to accept the Government-inspection so far as the strength of the airplane is concerned and to make a general inspection and appraisal. In handling insurance inspections we have found that the strength of the aircraft alone is only one of the elements involved. Local conditions under which the operations are carried on, the personnel, the flying-fields from which the machines operate, the terrain over which they fly, and the care with which they are maintained are equally important.

With reference to Major Young's paper, I might say that the Department of Commerce has relieved the insurance companies of a great deal of worry. The insurance companies have not seen fit, for the reason just suggested, to analyze the structure of every airplane offered for risk. They assumed that the structure was all right if approved by the department and confined their work to making inspections of the operating conditions. The licensing of aircraft by the department covered the matter of structural analysis.

The question has often been raised why an insurance inspection is necessary when we already have a Government inspection. I doubt if we can ever eliminate the insurance inspection entirely, for three reasons:

(1) The insurance company wants as recent information as possible on the condition of the aircraft, whereas the Government inspection might have been made a few months previously
(2) An appraisal is frequently included as part of the inspection. Obviously, no governmental department would dare attempt to place a value upon any equipment
(3) The insurance-company measure is taken in dollars, not in safety alone; there is a distinct and very important difference between the two

I suggest the desirability of more stress being placed upon the necessity of keeping log-books complete and that penalties for falsification of log-books be rigidly enforced, as in our inspections for insurance purposes we have to depend largely upon the records that are kept.

[4] M.S.A.E.—Consulting air-transport engineer, Garden City, N. Y.

Efficient Airplanes Would Be Penalized

J. Otto Scherer[5]:—It seems to me that the only true criterion of the factor of safety is what the airplane will actually stand after it has been in service for some time. There is, furthermore, only one way in which this can be done with any degree of accuracy, and that is by the rather expensive and cumbersome sand-load test. Machines could be picked at random from service and loaded, not to destruction, but to the required load-factor. This test should be used to supplement the regular inspection by the Department of Commerce men, and if one airplane of a certain type fails under the load test, another of the same type should be tested to determine whether the type, as such, does not come up to specifications, in other words, whether it has reached the end of its safe life or whether the individual machine was in poor condition. This method, though expensive, is the only sure means of determining whether an airplane will stand what it is supposed to stand.

This method would relieve the manufacturer who works accurately to very strict standards from the handicap of having to employ a load factor two or three points higher than necessary, which must be taken to cover the inaccuracies of the manufacturers who are not so careful in the selection of materials, nor so accurate in their work, but whose machines, on paper, look just as strong.

The safety factors required for various types is another subject. Mr. Stedman suggested that it should not be possible to break any airplane in the air. This would place a high penalty on the efficient machine, for the only one which, built with a reasonable load-factor, could not be broken in the air would be one which has such a high parasite resistance that its speed in a vertical dive is only a few miles an hour faster than in straight flight.

An efficient commercial airplane having low horsepower per pound must be aerodynamically clean, and such a machine may have a limiting speed in dive that is just as high as that of a pursuit airplane, and, if it is pulled out of a dive hard enough, it will be subjected to the same stresses as the pursuit airplane. If one tries to make it impossible to jerk the airplane out of a dive by using smaller control surfaces, the machine will have very poor maneuverability at low speeds, which is, perhaps, a still greater danger.

It seems to me that the only practical solution of this aspect of the safety problem is a rigid check of the pilots who fly the airplanes.

Safety Is Dependent upon the Manufacturer

C. H. Biddlecombe[6]:—I have been closely engaged in the sort of work covered in these papers. The thing that strikes me most forcefully in them is the feeling that there is a possibility of great difficulty arising in enforcing the regulations regarding safety. We found that to enforce cut and dried regulations regarding safety factors, airworthiness, and particularly material supply, was extraordinarily hard to do. Under European conditions we could not watch every manufacturer's sources of supply of material, test his material, watch his workmen and keep a paternal eye upon him.

Major Young points out that such a system would be very inimical to the industry. Of course it would; it would be costly and hindering. I think that the ultimate solution will be the common sense of the American aeronautical manufacturer and that we shall come to this. Regulation will be interpreted in common-sense ways, as it is now. We shall get safe, sturdy airplanes through the honesty and integrity of the manufacturers. Those who build up a reputation for turning out such aircraft will capture the whole market against men who try to scrape through the regulations.

A. H. G. Fokker[7]:—As a manufacturer I am very glad that in the United States we have not been bothered and hampered by the regulations. I have seen the disastrous effect of the organized and well-established regulations for airplane inspection in Europe. It is absolutely clear that it is impossible to supervise all aircraft and aircraft-building in the United States. The only way to inspect commercial aircraft successfully would be to put a Government inspector on every airplane in operation, which is impossible.

I agree absolutely with Mr. Biddlecombe. Successful aviation will develop automatically through the reputation of the manufacturers. Ninety per cent or more of all the existing manufacturers will go out of business. The same is true of the operators. All the "gypsy" fliers and "jennies" will disappear and the organizations that are able to maintain good uptodate aircraft and inspection will build a reputation for safe flying and will remain in business. I am glad that the United States has not taken over all the regulations they have in Europe. Aviation in this Country will develop to an extent that it never will be able to reach in Europe. One cannot fly in a privately owned airplane from Paris to Amsterdam or to Berlin, because he must have his own papers for each country and others for the pilot, and it takes 2 or 3 hr. to clear the papers.

Load-Factor Necessary for Non-Breaking Airplane

W. G. Brown[8]:—I was much interested in Mr. Stedman's comments on the difficulty of choosing a load-factor for airplanes that are clean in design and have a high terminal speed. It is theoretically possible to put a load of 30 or 40 times the weight of the machine on the wings of any of our military airplanes. Fortunately, however, nature has imposed a living condition on the pilot. Lieut. James A. Doolittle demonstrated at McCook Field that a pilot loses his ability to control the airplane when acceleration exceeds about 8 times gravity; so it seems that, if we design an airplane with a load-factor of 8 *g*. and make the direction stable, it would be impossible for a pilot to break it in the air.

E. W. Stedman:—In reply to Mr. Black on the cost of supervision by insurance companies, I may say that considerable money is being expended by governments on this inspection work at present and it might be possible to turn these funds over to the insurance companies to assist them.

Replying to Mr. Scherer, I fully agree that we are plainly concerned with the strength of the machine at the time it is used, but I have yet to find a constructor who will agree to load his airplane to the required load-factor.

On the question of breaking in the air, I tried all through my paper to make it clear that I did not stipu-

[5] Jun. S.A.E.—Chief engineer, Junkers Corporation of America, New York City.

[6] Consulting air-transport engineer, New York City.

[7] M.S.A.E.—President, Fokker Aircraft Corporation, Hasbrouck Heights, N. J.

[8] M.S.A.E.—Assistant professor of aeronautics, Massachusetts Institute of Technology, Cambridge, Mass.

late very great structural strength if the same results can be secured in some other way. Strength may be in direct proportion to the controls; it may be that springs will be used in the controls. Safety may lie in the limitations of the pilot himself, as suggested by Professor Brown; but the fact remains that it is not always necessary to strengthen the airplane to an exorbitant extent to preclude breaking it in the air. We hope to advance the science and find other ways of doing it without carrying extra weight. I entirely agree with the remarks of Professor Brown.

With Mr. Biddlecombe and Mr. Fokker, I agree fully that the answer is in the hands of the industry. I tried to make it clear in my paper that I would not increase our minimum requirements. My whole idea was to say it is for the designer to look after the good name of his company, of himself and of the aeronautical profession. That is the real answer, and reliable designers will be the ones to remain in the field, as suggested by Mr. Fokker.

INSPECTION OF OPERATORS' AIRPLANES MOST IMPORTANT

C. M. YOUNG:—Obviously, the inspection system that is maintained in some countries and by the Army and Navy in the United States is not practical or feasible in commercial aircraft construction. There is no tendency whatever on the part of the Department of Commerce to adopt such a system. The only inspection that will be needed is supervision of the manufacturer who is less interested in turning out a good airplane than the department is in having him do so. Unfortunately, some manufacturers at present are merely meeting scantily the minimum that has been set up, which in itself is not sufficient. One more point on inspection is that the manufacturer, good, bad or indifferent, has no control over the airplane after it is in the hands of the purchaser, and that is the important place for the inspection system of the department to function.

HARLAN D. FOWLER[9]:—As there is no possible way of preventing unusual maneuvers with exceptionally good airplanes, greater stresses than are contemplated under the commercial load-factors are developed. There is some chance of restriction under military supervision, but restrictions in the commercial field depend too much upon the ideas of the individual. Load factors should conform to acceptable military practice. If this policy is followed, it will standardize design and engineering data, and in times of emergency the airplanes could be depended upon for military purposes.

Some general rule should be recognized in the commercial field relative to publishing the low or stalling speed of an airplane, which is absolutely misleading in many instances. The competent designer or manufacturer would concur in the publishing of performance data conforming to a regulation acceptable to the Department of Commerce.

For the guidance of designers, an engineering compendium similar to that issued by the engineering division of the Air Corps would aid standardization. The adoption of the Army-Navy Standards should be recommended to the industry and means should be provided for keeping these uptodate for a nominal fee. There should also be a definition of whether the airplane's official number stays with the fuselage or with the wings in case of transference for experimental purposes or in event of a wreck.

[9] M.S.A.E.—Chief engineer, Miller Corporation, New Brunswick, N. J.

Correction in Mahan Paper

REFERENCES to the isolux curves in Figs. 4 and 7 in the text and captions of the paper on Airport Lighting, by H. E. Mahan, in the March issue of THE JOURNAL, inadvertently described these as Isolux Curves of Distribution of Vertical Illumination. The word "Vertical" should read "Horizontal." Mr. Mahan has called attention to the oversight in failing to make corrections as indicated on the carbon copy of the edited paper before its publication.

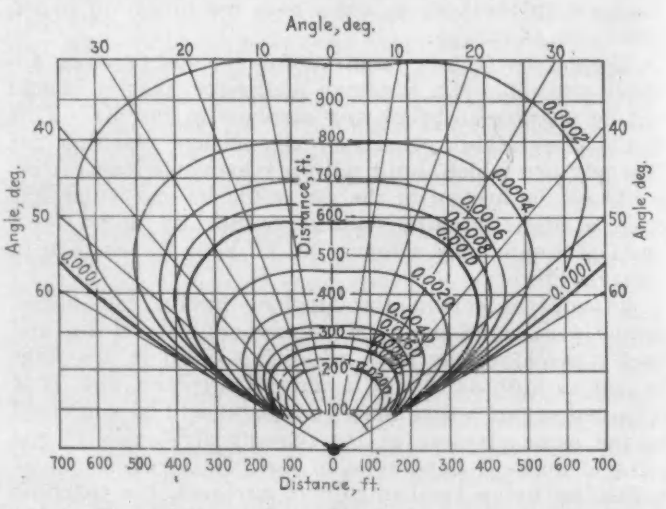


FIG. 7—ISOLUX CURVES OF DISTRIBUTION OF HORIZONTAL ILLUMINATION FROM SMALL 120-DEG. FIELD-LIGHT

These Curves Are for the Field-Light Shown in Fig. 6 with a 1000-Watt T-20 Mazda Lamp in Use

As the illumination values at the different curves were not given in Fig. 7, this figure is reprinted herewith, with the candlepower values inserted, together with a corrected caption.

Rail-Cars and Their Operation

By Walter C. Sanders[1]

Transportation Meeting Paper — *Illustrated with* Photograph, Drawings and Chart

Several distinct types of traction equipment now are needed to meet all the requirements of handling traffic on the railroads. Use of the self-propelled car, of the mechanical or gas-electric type, is the application of basic economic principals in railroad service.

Railroad passenger service in the future may be expected to include through passenger trains, supplemented by self-propelled cars on branches and on main lines to serve intermediate stations and connect with through trains at the express stops. This service will be supplemented by motorcoaches reaching "off-line" points and between various main-line railroad points where the travel is too light to warrant railway operation.

The rapid advance in the use of motorcoaches and motortrucks for short-haul traffic has, no doubt, accelerated the development of self-propelled rail-cars. The impression seems to prevail that the road vehicles are competitors of the steam train and the rail-car, but, if the facts regarding each individual run are determined, it will be found that in most cases they are complementary, not competitive.

Apparently the highway motor-vehicle has come to stay. Progressive railroad managers recognize this fact and are planning to utilize this new means of transportation as an aid to rail transportation. I believe that within the next decade the airplane will be utilized extensively by the railroads and become a part of their transportation systems. The motorcoach and motortruck also will be used extensively in connection with every trunk-line railroad in the Country.

In suburban territory there seems to be room for development of the rail-car in local freight service, with the use of containers whenever possible. It probably would mean the introduction of night "pick-up" service to a much larger extent than at present. It would permit also the elimination of coal and water stations, ash pits and other items of expense that are necessary in the case of steam freight service. Moreover, the actual economies effected by the use of self-propelled cars, together with the increased facilities offered to patrons for certain classes of traffic, are sufficient to warrant extensive experiments with this type of car.

Railroads of the future will supplement their through passenger trains to a greater extent with self-propelled local cars and motorcoaches.

The savings from substituting gasoline propelled trains for steam trains are illustrated by definite figures.

Ideals of rail-car design are outlined, and definite requirements for many units are listed.

Uniform records of reliability should be maintained.

Railroads should avail themselves of the economies of present rail-cars rather than await the development of improved engines.

The maintenance organization of the New Haven railroad is outlined in detail. Record forms are described, and the importance of comprehensive records is emphasized.

Adequate training is required for rail-car operators.

Considering the handicaps under which gasoline rail-cars entered railroad service, with their original light construction, they have made a remarkable record in a short time. The average operating cost of steam passenger-trains is about $1.10 per mile. The actual figures will vary from $0.60 to $2.00 per mile on typical branch-line service. Following are cost figures on a few gasoline rail-cars, including maintenance, interest on investment, depreciation, fuel, train supplies, wages of crew and all direct charges:

(1) Some Brill 38-passenger Model-55 gas-mechanical cars are operating for as little as $0.30 a mile, after 250,000 miles of service

(2) A few of the Brill 50-passenger Model-75 gas-mechanical cars are operating for as little as $0.35 a mile; a fair average being about $0.40 a mile

(3) The cost per train-mile of the Brill Model-250 gas-electric car, like that shown in Figs. 1 and 2, will range from $0.40 to $0.60, depending upon the condition of service, a fair average being $0.47 a mile

On the average gas-electric car the gasoline consumption is approximately 120 ton-miles per gal., although records are available of almost twice this economy. This means that 1¼ to 1½ miles per gal. will be obtained with an ordinary car weighing, with its load, 50 tons and drawing a trailer weighing 40 tons. The Boston & Maine Railroad places[2] the cost of operating a steam passenger-train, with no charge for roadway or rail maintenance, at $1.589 per mile; a gasoline rail-car at $0.72 per mile; and a motorcoach at $0.289 per mile. In rough figures, the self-propelled rail-car will operate today at approximately one-half the cost of the three-car steam train which it replaces; and a motorcoach will operate for about two-thirds of the cost of

[1] General manager, railway division, Timken Roller Bearing Co., Canton, Ohio.

[2] See *Railway Age*, Sept. 24, 1927, p. 622.

operating the smaller rail-cars and about one-half the cost of the larger ones.

The normal crew on a gasoline rail-car is two men, but several railroads use three men when the baggage is heavy, and the Narragansett Pier Railroad has operated with one man. This seems to be possible on branch lines where absolute block signals are in use.

Proper instruction for the operators of motor rail-cars is necessary. In many cases steam-locomotive engineers have used new rail-cars with only brief directions as to operating the mechanism. This leads to abuse of the mechanical parts and speedy deterioration which really is not the fault of the operator. The cooperative assistance of manufacturers should be used to advantage.

Trends in Rail-Car Design

Correct rail-car design should be based upon definite mechanical laws and facts, which can be determined only by carefully conducted and accurate experimental research and data that can be accumulated from the 600 rail-cars now in service upon American railroads.

economy considerations. There has also been much effort to render the powerplant as nearly fool-proof as possible, a requirement that is important because it often is necessary to place inexperienced operators in charge of cars without impairing the car's service.

There is no doubt that the gas-electric car is better suited to railroad requirements, as to both operation and maintenance, than is any other type of rail-car, and it undoubtedly will continue to be popular in the large sizes. Mechanical-drive cars made their début in the pioneer stages of the rail-car industry and suffer from the early imperfections in design; however, one railroad is obtaining high efficiency with a certain type of mechanical car. It is believed that, as a result of the experience which is now being gained, it will be possible in the near future to bring out a mechanical car much simpler in design and maintenance and lower in first cost and operating cost than has been possible up to the present time. Such a car, about 60 ft. long and capable of handling a 30-ton trailer in ordinary service, may bring a reversion to the mechanical type.

It may be that the development of double-powerplant cars has been carried too far for economy; but with these larger cars the railroads have been able to handle tonnage and meet other conditions without the restrictions that limit smaller equipment. It is common with double-powerplant cars to handle trailing loads up to 200 tons, and sometimes more if conditions are favorable. There are very few accommodation trains on American railroads that cannot be kept within this limit.

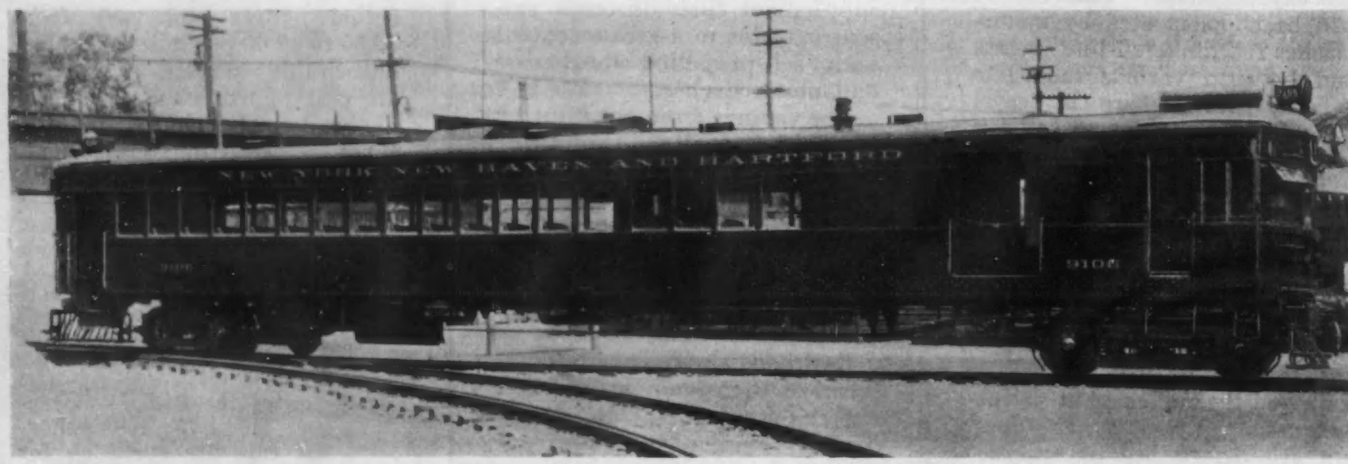


Fig. 1—Brill Model-250 Gas-Electric Rail-Car

This Car Is 60 Ft. Long and Accommodates 60 Persons in the Passenger Compartment. There Is Also a Baggage Compartment with a Folding Seat. The Plan Is Shown in Fig. 2

With the rapid increase in the use of rail-cars have come certain well-defined trends in the design and construction of both the cars themselves and their powerplants. The general tendency seems to be toward increasing the size and capacity, within limits that are set by differing economic and operating conditions on different roads. Other principal developments may be summarized as: Increased strength in construction, by the use of either better materials or better building methods; simpler and more accessible arrangement of powerplants; and modifications in design and construction that will tend toward both more efficient operation in terms of car-ton-miles and reduction of maintenance expense and service delays.

Development of the powerplants has been mostly in the directions of greater simplicity of control and more efficient combustion. Control improvements have been made in both mechanical and electric-drive cars. Efficient combustion possibly is more important in the gas-mechanical cars, since their fuel consumption depends more on the service conditions. Nevertheless, in both instances modern engine design is governed by fuel-

Rail-car manufacturers, as well as the railroads, should remember that the first necessities of the self-propelled car are reliability in operation and low maintenance charges. It would seem desirable to add 10 per cent to the first cost of a car if this would assure more reliable mechanical performance.

General Requirements of Design

In the design of a rail-car, the qualities sought are, in order of their importance:

(1) Absolute reliability
(2) Low maintenance and operating costs
(3) Long life
(4) Accessibility

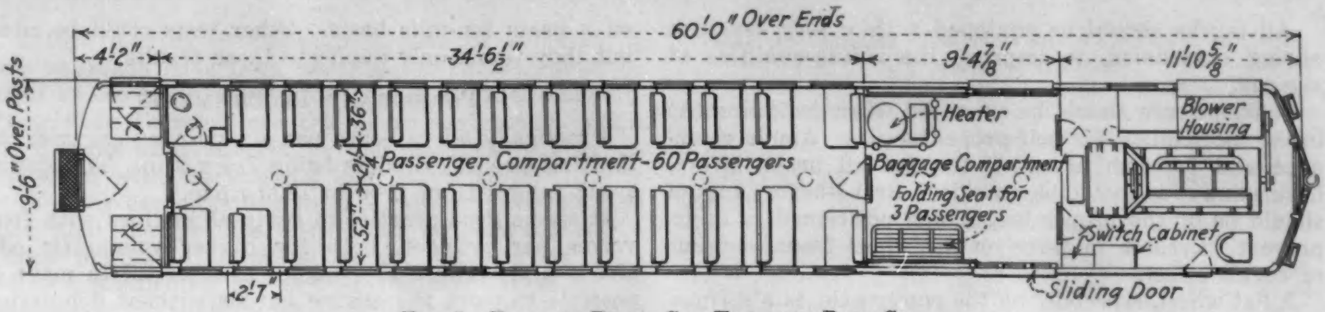


Fig. 2—Plan of Brill Gas-Electric Rail-Car

This Is the Same Car as Shown in Fig. 1. There Are Three-Passenger Seats on One Side of the Aisle and a Folding Seat in the Baggage Compartment

(5) Simplicity
(6) Reasonable first cost

With regard to operation, the items which must be given consideration are:

(1) Number of passengers and amount of freight, mail and baggage to be handled
(2) Operating conditions which must be met upon a particular run

Some of the general requirements of satisfactory rail-car design are as follows:

(1) The car should be of such construction as to make possible a higher schedule speed due to shorter loading and unloading time, more rapid acceleration and braking, and ability to operate faster, even over rough track
(2) Noise and vibration should be eliminated, so far as possible
(4) The car should have the most attractive lines possible
(4) Comfortable seats should be provided
(5) All bearings should be of the roller type
(6) The driving mechanism should be supported on springs rather than dead on the axles
(7) The axles, transmission and engine of the mechanical car should all be made more rugged
(8) The gears should run in a bath of oil in an oil-tight case
(9) The weight of car per horsepower should be reduced to the minimum
(10) The lighting fixtures should be of a new and attractive design
(11) The interior of the car should be attractive
(12) Heating and ventilation should be given careful consideration
(13) The car should have some distinctive warning signal
(14) The throttle and other operating levers should be made rugged and as much like steam-locomotive levers as possible, for the psychological effect upon the engineman
(15) The electrical installation should be remotely controlled, and high-voltage contacts should be made by means such that the operator need not handle dangerous currents directly

Lightness and Comfort in Bodies

The car-body frames and sills should be designed to meet the general requirements of standard railroad practice; but it is extremely desirable to reduce the weight in any way possible without increasing maintenance and repairs or sacrificing the safety of passengers in case of accident, which is of paramount importance. The elimination of a large part of the buffing shock in handling the cars will safely allow a reduction in section of some parts.

Aluminum alloys may be considered for reducing weight. They weigh about one-third as much as steel and cost per pound, in structural form, about 6½ times as much. Against this difference in cost should be credited the difference in scrap value. All material used in the car body should be rust resisting.

The comfort of the passengers should be given proper consideration in the design of the seats and in the general arrangement of the interior of the car. The arrangements of two gas-electric cars are shown in Figs. 2 and 3.

The Design of Car Trucks

Worm drive and double-reduction gears should be considered for gas-electric car trucks to eliminate the trouble and noise that are encountered with the direct axle-mounting of the motor. Each manufacturer of gas-mechanical cars has his own type of truck, and the ideal mechanical drive will be obtained by the process of elimination.

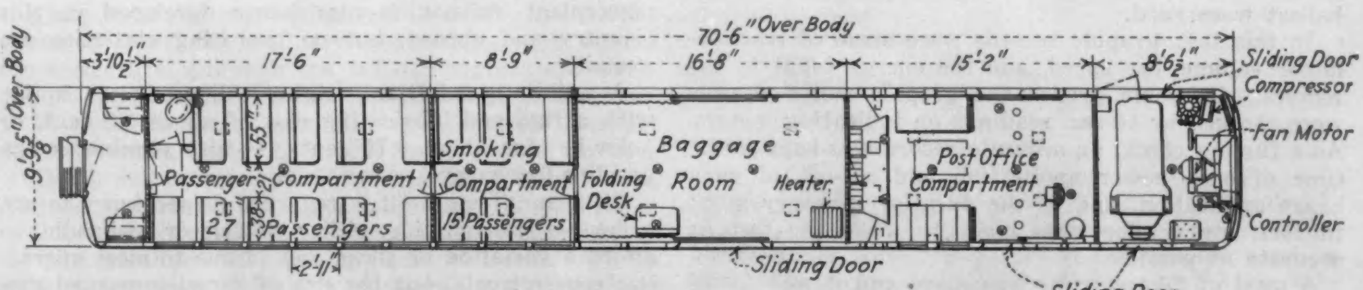


Fig. 3—Plan of Standard Electro-Motive Rail-Car

Five Separate Compartments Are Provided: Main, Smoking, Baggage, Railway Post Office, and Powerplant. The Engine Is Placed Crosswise. The Radiator Is on the Roof

All trucks should be equipped with a very sensitive spring suspension, to improve the riding-qualities of the car.

Extreme care should be exercised when designing the brake mechanism for self-propelled cars. Ample clearance and freedom of movement for all brake levers, beams and rods should be provided. Brake-beam hangers should be of the proper length and positioned so as to prevent increases in force on the wheel from wedging or toggle effect.

A flat wheel, especially on the power axle, is a serious matter with a rail-car, as it involves a great amount of labor to remove the axle-and-wheel assembly for grinding a one-wear wheel or turning a steel wheel. As it may be turned several times, the steel wheel should be more economical in the long run than the one-wear wheel. Wheels of both types now are in service under self-propelled cars, but no figures are available in regard to their cost per mile.

All self-propelled-car trucks should be equipped with roller-bearing journal-boxes, because the limited powerplant makes it essential to take advantage of every means possible to improve the load characteristics of the car proper, especially with respect to starting and acceleration.

Advantages of Roller-Bearings

Roller-bearings relieve the mechanical transmission or the electric drive of a part of the heavy shock of starting. The immediate saving in gasoline due to the use of roller-bearings may be as much as 15 per cent, and it is a mere question of time before the maintenance charges will indicate the folly of using plain bearings on equipment of this type. Roller-bearings also permit the use of gear ratios that will give a more economical performance for the car at high speeds.

Roller-bearings have been used very extensively on self-propelled gasoline coaches during the last few years and have given trouble-free service that has been the opening wedge for their use under heavy steam-railroad cars.

A test was conducted with two gas-electric trains operating in revenue service over a stretch of more than 200 miles, one train being equipped with roller-bearings and the other with plain bearings. The two trains were made up of cars as nearly alike in weight as possible, the actual totals being 172,360 lb. for the roller-bearing and 169-780 lb. for the plain-bearing train. The track on which the tests were run has an average up-grade in one direction of 0.056 per cent for one section and 0.081 per cent for the other. The rail section was heavy and there was a high proportion of tangent track. Both the track maintenance and the ballast were good.

In this test, graphic records were made of traction-motor voltage, car speed, and the energy input to the motors. On some grades the graphic meter records were checked by 10-sec. readings on indicating meters. As a further check, an accurate record was kept of the time of each power application and cut-off, of each brake application, and of the duration of every stop; in fact, every effort was made to make the test as accurate as possible.

A total of 26 test runs was made and it was found that, without considering corrections for windage or different track conditions, the power saving of the roller-bearing train amounted to more than 9 per cent on a gross ton-mile basis. Other tests could be cited, but they would only duplicate these results.

Powerplant Requirements

Practically all rail-cars use six-cylinder engines, the limiting size of cylinders being $7\frac{1}{2}$ x 9 in. The engine speed ranges from 1000 to 1200 r.p.m.

It seems good practice to equip all engines with four valves per cylinder, both for higher volumetric efficiency and because the smaller exhaust-valves make it possible to work the engine harder without detonation from excessive heat in the heads.

Engines equipped with sleeve-lined cylinders are to be preferred because replacements can be made readily and without great expense; because the cylinder-walls can be machined to uniform thickness, permitting uniform cooling; and because the sleeves are not subject to distortion with the warping of cylinder castings.

All parts of the engine should be lubricated under high pressure, and the design should be such that the engine will run indefinitely without wear at the main and connecting-rod bearings. The oil pressure should be regulated by a connection with the throttle, reducing the pressure with closed throttle to prevent oil pumping.

The crankshaft should be supported in the upper half of the crankcase, so that any wear on the main bearings can be corrected without dropping the crankshaft. It should be drilled through and a large volume of surplus oil be pumped through it, serving to keep passages clean and to cool the shaft—the last being a very important function.

Aluminum pistons can be fitted almost as closely as cast-iron pistons, and they make possible greater horsepower without distress, because of their high heat-conductivity. They also reduce the inertia loads.

Two or more carbureters to an engine result in higher power, better distribution and better economy than are possible with one carbureter. Two entirely independent magnetos should be used, for reliability.

A system of gasoline supply should be used that will avoid the need for pressure feed, large gravity tanks and liquid pumps, with their attendant danger of leakage and possible fire hazard. If the oil supply becomes low, the fuel should be cut off automatically.

There is considerable room for improvement in the design of heavy gasoline-engines for railroad service, as their limitations have not been reached.

Do Not Wait for Diesel Engines

The last few years have seen many interesting developments in the Diesel engine and a rapid widening of its field of application. The high-pressure steam-powerplant rail-car is also being developed in this Country and abroad, but no operating statistics are available.

A well-designed Diesel engine will produce 1 hp-hr. with a fuel and lubricating cost of about 0.5 cent, or 1 kw-hr. for about 0.75 cent. It also eliminates the gasoline fire hazard.

With an oil engine it is regarded as necessary to use a flexible transmission, either electric or hydraulic, to afford a variation of speed and torque to meet operating requirements, but the use of direct-connected mechanical transmission with the oil engine should be studied. A hydraulic-transmission car on the New Haven railroad has given fair results.

Before making extensive purchases of rail-cars, a few railroads have been waiting for further development of the Diesel engine because of its fuel economy. They have thereby lost the enormous saving which could have been effected by the gasoline rail-car as compared with the existing local steam train.

In many cases the design of a rail-car powerplant is such that the gasoline engine can be removed and a Diesel engine of improved design put into its place without disturbing the rest of the car. However, in most cases the savings are so large that within 3 years the entire car can be scrapped for an improved type and still show a fair return on the investment. For example, one group of cars has been operated more than 100,000 miles each, during 3 years, and has effected a direct voucher and payroll saving of at least 50 cents per mile, compared with the steam service replaced. The cars cost only about $17,000 each when new.

One of the secrets of the great efficiency of some modern manufacturing plants is their readiness to adopt new machinery, work it to its maximum capacity, and replace it in a short time if radical improvements are developed.

The New Haven railroad is an excellent example of the development of motor rail-cars. Its mechanical maintenance costs have been righer than those of some other railroads, at it has done much of the pioneer work and has purchased and tried out cars of a number of different types. This railroad has nevertheless saved enough money, compared with the cost of the steam service replaced, so it could scrap the older-type cars and still show a large saving.

All gasoline self-propelled cars should be so designed that the engines will cool equally well at any car speed in either direction. The fan drive and the radiator shutter should be designed so the operator can adjust them according to the run to give the desired temperature. The J. G. Brill Co. and the American Car & Foundry Co. have built some large gas-electric cars with the radiators in the roof. When the engine stops, the water will drain out, thus preventing freezing in cold weather. Radiators at the sides of the car must be connected to the car heater to prevent freezing during lay-overs in cold weather. The radiators mounted upon the roof are not subject to damage from collisions and they do not obstruct the engine room.

Durability and Reliability

Car bodies and trucks of any reasonable design usually are serviceable for 15 to 20 years. Therefore it is important that the engine, electric equipment and all accessories be extremely durable, as, even at the best, they will wear out before the car. Some rail-car engines have run more miles before having the carbon removed than the ordinary automobile runs during its entire life, although the rail-car engines are working at from one-half to full capacity most of the time.

If rigid inspection schedules are followed it is not entirely unreasonable to expect these engines to have a life of well up toward 1,000,000 miles, cylinder liners, pistons and rings being renewed each 150,000 miles.

Considerable criticism has been made of unreliability of the gasoline rail-cars on some railroads, but on others they give reliable performance and continuous operation unequaled by any steam service. In one case a rail-car, without any breaking-in following its delivery, was operated 150 miles every day for 6 months with only two delays of 10 min. each, caused by mechanical trouble; and then it went to shop only because of a collision with an oil truck. The car was held each night away from a mechanical maintenance point.

TABLE 1—RAIL-CAR OPERATING COSTS IN CENTS PER MILE

Type of Equipment	Mechanical, Single	Mechanical, Trailer	Electric, Single	Electric, Trailer
Crew	18.69	22.93	18.85	20.79
Fuel	4.59	6.05	10.45	12.10
Lubricating oil	0.86	0.90	0.88	1.00
Supplies, Cleaning, Engine-house	2.83	3.12	1.66	2.10
Repairs	11.40	10.85	6.31	5.45
Total	38.37	43.85	38.15	41.44
Average Daily Mileage	101	122	165	203

Cost of Operation

The Committee on Automotive Rolling Stock of the American Railway Association states[3] that, although the direct operating expenses of gasoline rail-cars are distinctly less than those of branch-line steam service, they do not constitute the entire saving; it has frequently been found possible to avoid the expenses of maintaining coaling and water stations, turntables, ash pits, and the like, and to rearrange the runs, and to concentrate facilities in a relatively few modern engine-houses. The actual values of these somewhat intangible savings are not easily obtained, but they are not inconsiderable.

Typical operating costs of rail-car equipment collected from several class I railroads by this committee are shown in Table 1. It has been necessary to condense and group certain items for ready comparison. Obviously, the age of the cars and the average daily mileage must be given due consideration in making comparisons.

Considerable variation was found by the committee in the methods of recording performance on various railroads, especially with respect to the measure of reliability in terms of miles per detention and miles per total failure. The performance records, on a comparative basis from the data collected from several Class I railroads, are shown in Table 2.

TABLE 2—RAIL-CAR PERFORMANCE RECORDS

Road	Serviceable Days, Per Cent: Mechanical	Serviceable Days, Per Cent: Electrical	Miles per Total Failure: Mechanical	Miles per Total Failure: Electrical
Boston & Maine	74	...	.....	.....
Canadian National	95.3	81.7[a]	.....	9,112[a]
Central Vermont	...	96	15,000[b]	.....
Chicago, Burlington & Quincy	87	...	.....	.....
Chicago Great Western	86	94	9,576	17,207
Chicago & North Western	66	...	.....	.....
Erie	79.1	95.4	.....	.....
Lehigh Valley	87.7	97.6	15,951	No Failures
New York, New Haven & Hartford	73.3	93.1	11,570	38,900
Pennsylvania	85.7	91.4	24,070	48,235
Reading	94.5	83.6	2,873	8,722
Southern Pacific	70.5	...	37,428	.....
Union Pacific	8[illegible]1	...	22,724	.....

[a] Diesel electric.
[b] Storage-battery.

[3] Report of April 25, 1927.

It will be of great assistance in solving the rail-car problem if railroads operating the cars will keep uniform comparative records on delays, failures and their causes.

The same committee found in its investigation that the average unloaded weight in pounds per horsepower for rail-cars is about as follows:

Single, mechanical, 350; electric, 400
With trailers, mechanical, 630; electrical, 750

The weight of small mechanical cars is approximately 750 lb. per ft. of length, and of large mechanical cars, 1100 lb. Electric-drive cars average 1400 lb. per ft. of length, the additional weight being due in part to the increased weight of the transmission and in part to the fact that these cars have, in general, heavier-duty engines and are of more substantial construction throughout.

Maintenance of Prime Importance

For the proper maintenance of rail-car equipment, adequate facilities must be available at the various points where the cars lay over. Shelter and heat must be provided in the winter, and gasoline fuel-pumps of adequate size should be installed. Means for the charging of batteries, in addition to the usual charging apparatus mounted on the car, are generally necessary. Supplies of oil, grease and spare parts, hydrometers for testing batteries, and grease guns are necessary for proper maintenance. Although it may not be advisable to make large expenditures for facilities at some points, because of the indeterminate length of the run assignment, it is advisable and necessary to install uptodate facilities at the more important points. In roundhouses where rail-cars are quartered with steam locomotives, it is advisable to install partitions to protect the cars from soot and smoke. Frequent washing and cleaning of the cars is necessary so they may be attractive to the riding public.

Economical maintenance also involves the coordination of stores-department work so that cars will be out of service for the minimum length of time awaiting material. The increased cost of steam service required while a car is in the shop would pay for many a telegraphic requisition or express shipment of material.

In general, it is safe to say that, with reasonable maintenance, rail-cars will be more reliable than steam locomotives and should be on a par with the electric locomotive. It is interesting to note that a check of detentions and failures indicates that these are invariably caused by some minor item such as a lighting switch, a fuse, failure to lubricate the engine, or water or dirt in the fuel lines, most of which could be eliminated by careful maintenance.

The railroads are rapidly building up organizations for handling rail-car maintenance and repairs properly. Gasoline rail-car operation is still in its infancy and will require careful watching and mature thought to determine future policies and procedure, which must of necessity be based on experience. The New Haven railroad was a large user of gasoline rail-cars as far back as 1922, but it was not until 1925 that it decided to create a separate organization to give special treatment to rail-car operation. This railroad has made considerable progress in handling its equipment and has made an excellent record.

The automotive car organization on the road is made up of a supervisor of automotive equipment, with an assistant and three specially qualified rail-car inspectors reporting to the supervisor. The duties of the inspectors are to qualify operators, inspect cars under their different jurisdictions, and make minor adjustments for the local maintenance forces at detached points. One inspector covers lines west and another lines east of Willimantic, and one is located at the principal repair-shop in New Haven. This organization handles also the electrical work, so that the entire rail-car structure comes under one head.

Maintenance at local points is handled by the local master mechanic and shop superintendent, who have organized special squads of rail-car mechanics. The supervisor is somewhat of a free-lance and consults with all officials concerned with gasoline rail-car design, operation and maintenance.

In connection with building up of the rail-car organization, special attention was given to the vital necessity of having accurate records and statistics available for analyzing the performance of the various cars.

Following are descriptions of some of the records and statistics of rail-car performance kept on the New Haven railroad:

Gas Rail-Car Inspection Record.—This form, shown in Fig. 4, is used for checking the items of equipment specified for inspection. A card is made out for each car each week and forwarded to the supervisor's office, where it is filed. If the inspector finds that certain parts of the car need repairs, he makes out a yellow form that goes directly to the foreman in charge of the work, with copies to the master mechanic and the supervisor of motor equipment so that a complete check may be had on repairs made. These cards call for a terminal inspection, as well as a car inspection, each week; also a report on any failures that have occurred since the last card was filed.

Gas Rail-Car Maintainer's Record.—This form is distributed to all rail-car employees under the master mechanic and a card is filled out monthly for each car maintained. Comparing the maintainer's cards with those of the inspection department gives a very close check of local conditions and maintenance.

Lubrication charts.—On these are listed the various lubricating points of the different gasoline-electric, gasoline-mechanical and gasoline-hydraulic rail-cars used on the New Haven railroad. Opposite the name of each lubrication point are listed the various brands and grades of lubricants to be used, together with the names of their manufacturers. In several cases a choice is given among the products of three manufacturers. Where desirable, specifications for both summer and winter lubrication are given. Cards like these are nailed to the walls at the various maintaining points and are placed in the engine rooms of the cars and wherever else they may be useful.

Monthly Gas Rail-Car Lubrication and Fuel Record.—When taking on a supply of gasoline, the amount disbursed is recorded by the engineman on one of these forms, which are supplied for each car. The local maintainers make a record of the quantities of lubricants used. These cards, which are signed each month by the master mechanic in charge, call for information covering the kind of lubricant and gasoline used, as a cross-check on the lubrication chart.

Monthly Summary of Gas Rail-Car Failures.—This form is filled out each month by the mechanical department statistical forces. It indicates each failure of every car, with the mileage and the car miles per

failure obtained during the month. This summary is very complete, being divided into two sets of main headings and subdivided to itemize detail parts of the car. A monthly summary of this type, distributed to all outside maintenance points, stimulates competition among the different divisions and enables the officials to keep in close touch with the situation without going into numerous unnecessary details.

Gasoline Car and Train Car-Miles.—This statement shows the mileage each car on the system is operated, together with the division over which the mileage is obtained and the hours of operation.

Recapitulation of Average Gas-Car Mileage per Day.—This record shows details in connection with the serviceability of cars in operation and indicates the improvement or decline in monthly performance and time in the shop.

Equipment and System Statistics.—A graphical chart is plotted showing for ready reference the monthly figures pertaining to each kind of equipment for the following items: (*a*) failures per month, (*b*) repair costs per month, (*c*) per cent of serviceable days to total days, (*d*) car miles per failure, (*e*) car shop days.

Distribution of Rail-Car Failures by Causes.—This record makes possible at a glance a comparison of the failures of the engine, transmission, auxiliaries and gasoline system.

Failures by Runs.—A graphical record of the failures experienced on the different runs assists in fixing the extent of responsibility of local maintaining forces.

Engineering Changes.—This is a record of the different engineering changes made on the cars by the railroad.

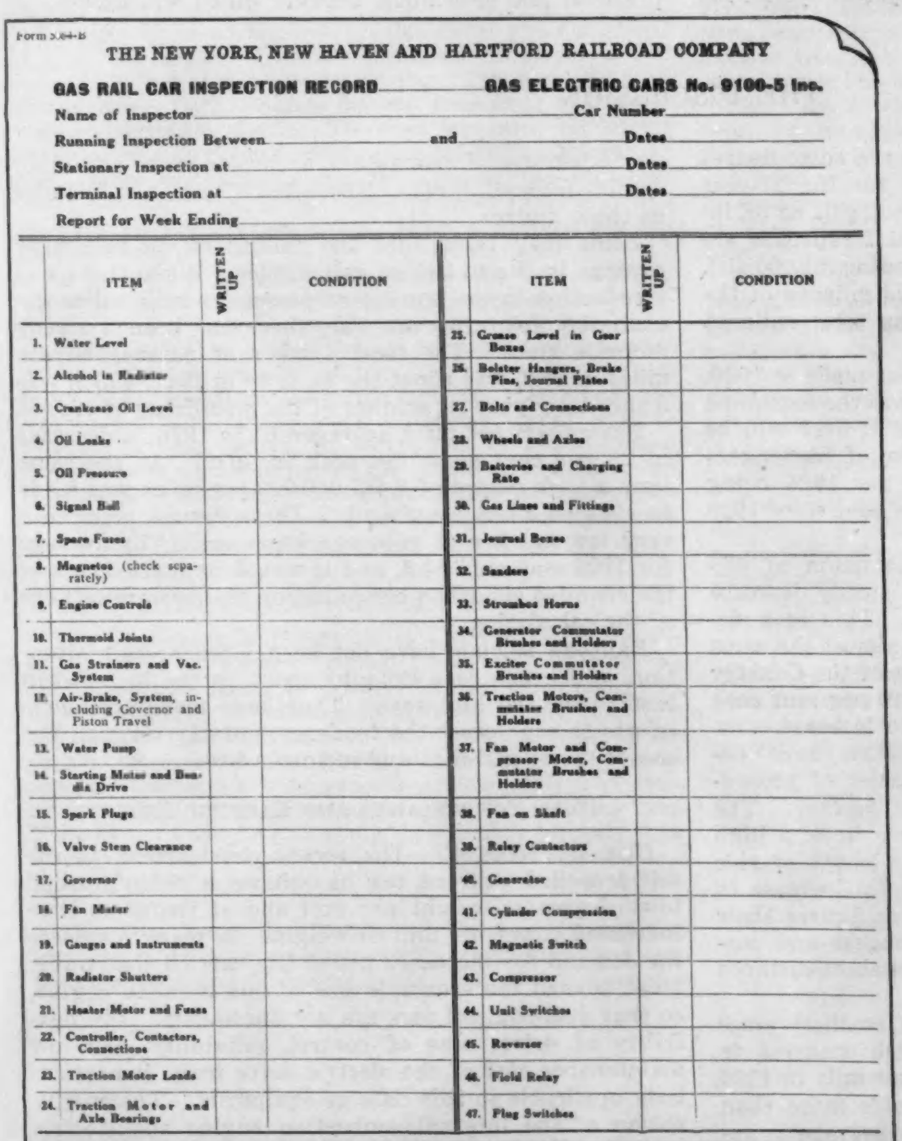
Shopping and Failure Statistics by Days.—A chart is kept showing daily shopping and performance records of each car on the system so that, by observing the chart, a complete record may be had of its performance during the year.

Before each car is released from the shops after undergoing general repairs it is subjected to a test over a certain section of line with severe curvature and grades. Stop-watch readings are taken at the signal posts on various sections of this run and the car is required to show a certain mechanical performance before it is replaced in service.

During the early use of mechanical cars on the New Haven railroad, a large number of failures were directly chargeable to improper operation. To eliminate these it was decided to tighten up on the qualification requirements of the operators. Now each operator of a gasoline rail-car is required to carry with him a card, similar to an automobile driver's license, indicating that he is qualified on that particular type of car, such qualification being vouched for by the personal signatures of the master mechanics and rail-car inspectors on the card.

This procedure has been helpful. It is the duty of the inspectors to qualify men at the request of the division superintendent. As soon as a man has been qualified he is reported to the superintendent and others concerned, and his name is entered on the usual form supplied by the railroad. An applicant is not allowed to qualify in revenue service but must go through a course of instruction. He also must answer a questionnaire pertaining to the cars. The questionnaire examination is given by the rail-car inspectors. It is necessary for an operator to requalify after an absence of 6 months. The engineman should be given careful instruction in the use of the brakes to prevent sliding and flat wheels. Heavy brake-applications should be avoided, particularly when rail conditions are bad.

The New Haven railroad found that the setting up and handling of



Form [illegible]

THE NEW YORK, NEW HAVEN AND HARTFORD RAILROAD COMPANY

GAS RAIL CAR INSPECTION RECORD — GAS ELECTRIC CARS No. 9100-5 Inc.

Name of Inspector ________ Car Number ________

Running Inspection Between ________ and ________ Dates ________

Stationary Inspection at ________ Dates ________

Terminal Inspection at ________ Dates ________

Report for Week Ending ________

	ITEM	WRITTEN UP	CONDITION		ITEM	WRITTEN UP	CONDITION
1.	Water Level			25.	Grease Level in Gear Boxes		
2.	Alcohol in Radiator			26.	Bolster Hangers, Brake Pins, Journal Plates		
3.	Crankcase Oil Level			27.	Bolts and Connections		
4.	Oil Leaks			28.	Wheels and Axles		
5.	Oil Pressure			29.	Batteries and Charging Rate		
6.	Signal Bell			30.	Gas Lines and Fittings		
7.	Spare Fuses			31.	Journal Boxes		
8.	Magnetos (check separately)			32.	Sanders		
9.	Engine Controls			33.	Strombos Horns		
10.	Thermoid Joints			34.	Generator Commutator Brushes and Holders		
11.	Gas Strainers and Vac. System			35.	Exciter Commutator Brushes and Holders		
12.	Air-Brake, System, including Governor and Piston Travel			36.	Traction Motors, Commutator Brushes and Holders		
13.	Water Pump			37.	Fan Motor and Compressor Motor, Commutator Brushes and Holders		
14.	Starting Motor and Bendix Drive						
15.	Spark Plugs			38.	Fan on Shaft		
16.	Valve Stem Clearance			39.	Relay Contactors		
17.	Governor			40.	Generator		
18.	Fan Motor			41.	Cylinder Compression		
19.	Gauges and Instruments			42.	Magnetic Switch		
20.	Radiator Shutters			43.	Compressor		
21.	Heater Motor and Fuses			44.	Unit Switches		
22.	Controller, Contactors, Connections			45.	Reverser		
23.	Traction Motor Leads			46.	Field Relay		
24.	Traction Motor and Axle Bearings			47.	Plug Switches		

FIG. 4—RAIL-CAR INSPECTION RECORD FORM
One of These Forms Is Filled Out for Each Rail-Car on the New Haven System Every Week and Filed in the Supervisor's Office

gas-car spare-parts stock has taken more time to organize and complete than any other one item undertaken by its gasoline rail-car organization. During the early stages of rail-car development it was found that serious delays were frequently chargeable to delay in obtaining parts. It was decided to begin at once a concentrated campaign on the material situation in general. The first undertaking was to prepare a rail-car spare-parts schedule, stating just what items should be carried in stock and at what points they should be located, on a minimum supply basis per month. This necessitated going through the manufacturer's entire schedule of material on each type of car and preparing a spare-parts schedule to be religiously lived up to by the storekeepers and the entire rail-car organization.

At the time the material sheets were issued it was found necessary also to prepare instructions covering the method of handling material, that is, just what procedure should be adopted in case of emergency to get material quickly without the usual formalities.

To expedite local shipments on the system special red tags were printed, with instructions to the local baggagemen to give emergency handling to shipments so labeled. Recently there has been issued a revised set of material sheets based on the actual movement of material through the shops for the last 12 months, which is the only economic basis on which to prepare a schedule. As a result of these measures the material troubles now are negligible, and it is reasonable to believe that a large saving in time and money has been effected.

Conclusion

The primary reason for the use of rail-cars is economy in operation. Their savings are both tangible—in fuel, maintenance and direct operating expenses; and intangible—in the elimination of coaling and water stations, ash pits, turntables and general engine-house expenses necessary for steam-locomotive operation.

Since the railroads are becoming more familiar with the possibilities of the self-propelled car they very likely will extend their rail-car operation, because of the practical and economical benefits which will accrue.

THE DISCUSSION

CHAIRMAN H. C. CROWELL[4]:—There are some figures in the statistics of Class I railroads for the 11-year period from 1916 to 1926, inclusive, that will be of interest to automotive engineers. (Class I railroads are those having an annual revenue exceeding $1,000,000. They include 90 per cent of the railroad mileage of the Country and earn 96 per cent of the total railroad revenue.)

A high record for total passengers was made in 1920, the number being 1,235,000,000. This was the maximum for all time, and we do not know that it ever will be reached again. Since then the number of passengers has been declining steadily, the total for 1926 being 862,000,000, that is, a decrease of 30 per cent since 1920 and 15 per cent since 1916.

Passenger-miles also reached the maximum of 46,849,000,000 in 1920. There has been a steady decrease since then, to 35,478,000,000 in 1926. This is a decrease of 24 per cent since 1920 and is almost the same as the total for 1916. As the population of the Country has been growing at the rate of about 10 per cent each decade, we might expect these figures to increase.

It should be noted that passenger-miles have decreased less rapidly than the total number of passengers. This indicates a longer average journey. The average journey in 1926, which I believe to be a high record for all time, was 41.2 miles. The length of ride has increased steadily since 1916, the total increase in the 10 years being 20 per cent. Further figures show that the falling off in number of passengers and passenger-miles has been almost entirely in short-distance riders; not in through traffic.

Passenger revenue in 1926 was the smallest since 1918; 19 per cent below the peak, which occurred in 1920. The average revenue per passenger-mile in 1926 was 2.94 cents. While some traffic yields more than the basic rate of 3.6 cents per mile, the average is reduced because of commuters, excursion rates and other special reduced fares. "Dead-heads" are not included in these figures.

Some may think that the falling off in passenger revenue is due to lack of rail service. While there was a reduction in the number of passenger-train miles immediately following the war, there has been a steady increase since. The total number of passenger-train miles in 1926 was about the same as in 1917, which was a very busy year on account of the mobilizing of troops.

Passengers per train averaged 61 in 1926; a decrease of 28 per cent since the peak in 1919. At the same time a high record of 2,487,000,000 car-miles was made in 1926 on Class I railroads. These figures point to a very low number of passengers per car. The average for 1926 was only 14.3, and it would be much lower if the crowded suburban commutation trains were left out of the calculation.

Railroad officials have not been blind to this situation, which has been brought about by the increase in traffic over the highways. They have made strenuous efforts to counteract the tendency, notably through the use of motor rail-cars and motorcoaches.

Dual Powerplants and Electric Drive

GUY W. WILSON[5]:—The recent development of the self-propelled railroad car has shown a definite trend toward greater weight per unit and at the same time increased power per unit of weight. In many instances the demand for increased power has carried the powerplant beyond the economic size of one gasoline engine, so that dual-engined cars are not uncommon. The flexibility of drive, ease of control, reliability, and low maintenance cost of the electric drive make it particularly applicable to this class of equipment. The coordination of the internal-combustion engine and electric transmission allows simplicity in construction and flexibility in arrangement of apparatus which facilitates inspection and maintenance.

D. C. HERSHBERGER[6]:—Although frictional resistance

[4] Assistant chief engineer, Pennsylvania Railroad Co., Philadelphia.

[5] M.S.A.E.—Engineer, General Electric Co., Schenectady, N. Y.

[6] General engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

absorbs only a small part of the energy required to move a train, the effects of improved bearings are remarkable. Some tests in which I cooperated with the Timken Roller Bearing Co. showed that, with gasoline at 15 cents per gal., roller-bearings would make a saving of $430 per year on a two-car train running 200 miles per day. They would pay for themselves in about 3 years.

Why Some People Have Bad Luck

THE suggestion has been made that we should test candidates on the kinds of skill that are believed to be actually required in driving. There are two alternatives here. One is to test candidates on their actual ability as drivers under traffic conditions. The other is to test them more exactly in certain kinds of elementary skill which would seem to be required in driving. A number of ingenious devices have been put forward for this latter purpose, mainly depending on the measurement of the reaction time; namely, the quickness with which the candidate can make a hand or foot movement in response to a sudden signal.

I believe all these methods are fallacious and dangerous if they are depended upon. Quickness of response, for example, is not a requisite in driving. The requisite is to do the proper thing. Safety depends frequently upon making the responses slowly. The man who sets his brakes with a snap may cause a serious accident to the man behind him. More complicated tests fail because the responses under test conditions are no index of what the driver will do when on the road or street, where conditions are entirely different.

As for tests of actual driving, such as are now employed in various places, where an officer accompanies the candidate in his car and directs his operations in traffic, these are unquestionably useful but not as means of selection. All candidates eventually get by. The real value of these practical examinations lies in the fact that they compel the learner really to try to learn something, or at least to practise driving, before he starts out as a full-fledged driver. It is a good thing for the examiner to flunk a few candidates to stimulate to more practice on the part of the candidates generally. Even if he flunks the wrong ones it makes little difference, as a week or so more of practice is not a serious hardship.

Training as a Safety Factor

This consideration brings us to another factor in the improvement of drivers; namely, training. This is the most important factor in safety. The drivers who are by nature incapable of learning to drive safely are relatively few and may be eliminated. The important thing is the proper training of the others. Unfortunately, a large number of drivers are not properly trained. Many of them are untrained in the elementary details of controlling cars. They do not know how to apply their brakes properly, how to change gears properly, how to start their engines, how to avoid skidding, or how to manage their cars at a railroad crossing.

The more important feature of learning, however, is learning to drive in accordance with traffic rules, and here the greatest source of danger exists. The man who has not learned to obey the rules is to be considered as ignorant, just as the man who has not learned to shift gears. Obeying the rules, or not obeying them, is a habit, like gear-shifting, and should be as automatic on the part of the driver.

Rules Unlucky Drivers Neglect

What are the rules the unlucky drivers do not follow? They are numerous: to slow down at corners; to keep to the right going around corners; not to overtake on a hilltop; to hold out the hand before stopping or turning; to give pedestrians the right of way; to approach all intersections cautiously, and so on. These are the lucky rules. The man in trouble has usually broken one of them, or some other driver has broken one and made him the goat.

There are no simple cures for carelessness and recklessness, the two grand divisions of unsafe driving. Yet, from the general store of psychological facts and principles we can point out certain types of training of the driver which do conduce to safe driving; and we can suggest, tentatively at least, certain ways in which such training may be applied.

Schools for drivers who show signs of incompetence should be seriously considered. There are great numbers of borderland cases, in which the driver shows slight incompetence and is either reprimanded by the officer or taken to the court and made to pay a small fine, where the better plan might be to sentence the suspect to a training school or training course, with no prejudice to his record.

Conditions That Driving Rules Must Meet

The habit of obeying traffic rules is the most important desideratum. This is a matter of learning, just as much as the habit of stopping without stalling the engine, shifting gears smoothly and avoiding skidding are matters of learning. The man who is sloppy about traffic rules has failed to learn a habit which he can certainly be required to learn.

The development of the general safety habit is a complicated and difficult matter, but although the training-school plan for some offenders seems worth trying, law enforcement is not the only end. The important preliminary and supporting factor is in the rules themselves and the accessories of the rules. Little can be done toward the attainment of safe habits until certain requirements are met by the rules. They must be

(1) Uniform
(2) Reasonable
(3) Consistent
(4) Clear and unmistakable
(5) Easy to follow in all ways

—Knight Dunlap, in *Public Safety.*

Volatility and Detonation

Discussion of Edgar[1], Bridgeman[2], Cummings[3] and MacCoull[4] Annual Meeting Papers

DISCUSSION following the four papers dealing with volatility and detonation which were presented at the Research Session of the 1928 Annual Meeting was both oral and written. After having submitted the edited copy to the several authors and discussers for their correction and approval, the discussion is printed herewith.

Some of the main subjects included are: An illustrated discussion of maximum detonation pressures, by L. C. Lichty; a demonstration of the different results that can be obtained from exactly the same test, depending on whether the fuel is gaged by the power at start of detonation, the spark-advance at start of detonation, the maximum power obtainable, of the spark-advance giving maximum power, by J. H. Geisse; recommendations that the air-fuel ratio and the temperature be standardized, by H. M. Jacklin; recommendations that some standard method of testing be adopted, by G. G. Brown; and comments on the necessity for developing a common language so that work along the lines of viscosity and detonation can be better correlated, by H. L. Horning, H. M. Crane and W. E. Lay.

Comments are made by A. Ludlow Clayden on methods of standardizing air-fuel ratio. It is brought out by Hon. Edward P. Warner, in the interest of aviation, that one very promising way to improve engine performance is the provision of better fuel to be universally available upon flying fields, and that a necessary preliminary to the general availability of such a fuel is the development of means of specifying antidetonant qualities clearly, tangibly and positively. Dr. Edgar's classification of the methods used for determining the amount of tetraethyl lead necessary to equate the four samples to sample 5J is discussed by J. B. Hill. Charles O. Guernsey refers to the desirability of arriving at a common standard for measuring and listing detonation characteristics, and says that he prefers the method whereby fuels are calibrated on the basis of the amount of compression which they will withstand in a designated type of engine without detonation. It is said by A. L. Beall with regard to standardization that it seems to him more important to standardize in terms of the fuel, allowing all investigators full latitude in the means of securing results rather than to attempt to limit a small fraction of the many mechanical variables. He says further that, after all, these results are not an end in themselves, and their usefulness is dependent on their utilization for two purposes. One is to enable the automotive engineer to determine the fuel limitations of his engine. The other is to enable the refiner to determine that his fuel is suitable for engines in the field in which he markets.

L. C. LICHTY[5]:—An investigation of the subject of detonation in an internal-combustion-engine cylinder is under way at Yale University, and a description of some preliminary work is offered herewith which seems to give promise of throwing more light on this particular process. Some theoretical computations have been made in an effort to predict the maximum possible detonation pressures and, as is always the case, there will be the usual discrepancies between theoretical and actual results.

The idea made use of was suggested by the work done by Thomas Midgley, Jr., in 1922, which was reported in his paper entitled Molecular Movements during Combustion in Closed Systems[6]. The method employed is similar to that of Rosecrans, and is described in his article entitled An Investigation of the Mechanism of Explosive Reaction[7], in 1926, and also to that of Marvin as described in a report[8].

The method followed is indicated in Fig. 1. This illustrates a combustion-chamber in which a certain portion of the charge is burned at constant volume. The data of Goodenough and Filbeck on Variable Specific Heats and Dissociation[9] are made use of in this work. No heat losses are considered. After burning at constant volume, the burned gases are at higher pressure and temperature than the unburned gases are; the one portion expands, losing energy, and the other portion is compressed, gaining the same amount of energy, and, finally, a uniform pressure exists in the combustion-chamber. It is then assumed that the unburned portion detonates, and it is also assumed that the flame-front has enough inertia so that the combustion process, now termed detonation on account of its rapidity, takes place at constant volume.

In the foregoing manner, for various flame-front positions, pressures and temperatures have been computed for both the burned and the detonating portions of the gases for gasoline, C_8H_{18}; benzene, C_6H_6; carbon monoxide, CO, and hydrogen, H_2. The results shown in Fig. 2 for gasoline and benzene are practically identical; likewise for carbon monoxide and hydrogen.

As the flame proceeds through the combustion-cham-

[1] Director of research, Ethyl Gasoline Corporation, Yonkers, N. Y. The paper was printed in the January, 1928, issue of THE JOURNAL, p. 41.

[2] Research associate, Bureau of Standards, City of Washington. The paper was printed in the April, 1928, issue of THE JOURNAL, p. 437.

[3] S.M.S.A.E.—Associate physicist, Bureau of Standards, City of Washington. The paper was printed in the April, 1928, issue of THE JOURNAL, p. 448.

[4] M.S.A.E.—Automotive engineer with research duties, The Texas Co., New York City. The paper was printed in the April, 1928, issue of THE JOURNAL, p. 457.

[5] M.S.A.E.—Assistant professor of mechanical engineering, Yale University, New Haven, Conn.

[6] See THE JOURNAL, May, 1922, p. 357.

[7] See University of Illinois Engineering Experiment Station Bulletin No. 157.

[8] See National Automobile Chamber of Commerce Report No. 276.

[9] See University of Illinois Engineering Experiment Station Bulletin No. 139.

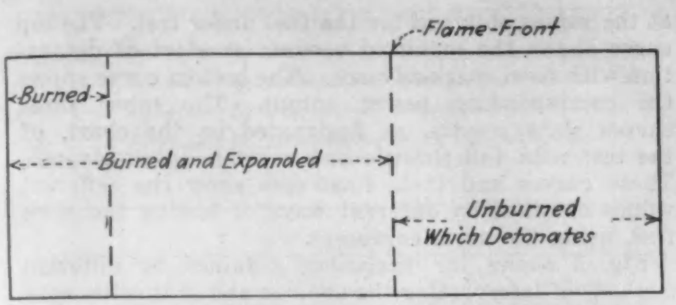


FIG. 1—THE DETONATION PROCESS

A Combustion-Chamber Is Shown in Which a Certain Portion of the Charge Is Burned at Constant Volume, after Which the Burned Gases Are at Higher Pressure and Temperature Than the Unburned Gases Are. The One Portion Expands, Losing Energy, and the Other Portion Is Compressed, Gaining the Same Amount of Energy, and, Finally, a Uniform Pressure Exists in the Combustion-Chamber. It Is Then Assumed That the Unburned Portion Detonates. It Is Also Assumed That the Flame-Front Has Enough Inertia So That the Combustion Process, Now Termed Detonation on Account of Its Rapidity, Takes Place at Constant Volume

ber the pressure rises gradually at first and faster as the flame nears the end of its path. As pointed out by others, the flame-front has progressed through 50 per cent of the combustion-chamber volume when approximately 20 per cent of the charge has been burned. The detonation pressures start at the maximum pressures attainable by instantaneous combustion of the charge and run as high as 2200 lb. per sq. in. for gasoline. Later, however, it will be shown that such pressures are practically impossible.

The temperature of the unburned portion experiences a considerable rise as it is compressed by the oncoming wave-front. Assuming that detonation will occur when the unburned portion reaches a temperature of 1300 deg. fahr., absolute, the flame-front position is at 0.75, the combustion pressure is 295 lb. per sq. in. and the pressure reached by the detonation could not be above 1350 lb. per sq. in. Actually, the detonation pressure will be less, due to heat loss, dilution of the charge by burned gases left in the combustion-chamber, and also due to the flame-front not holding the detonation to a constant-volume process.

It is interesting to note that shifting the curve labeled "temperature of unburned" 50 deg. one way or the other merely shifts the position of flame-front when detonation occurs and, for the foregoing illustration, would not eliminate the detonation but would vary its intensity, depending upon the actual detonation-pressure curve for that range of flame-fronts.

Reverting to the maximum-detonation pressures, the possibility of obtaining constant-volume detonation will depend upon the inertia and the kinetic energy of the flame-front, as well as the pressure of detonation. At the beginning of the process, shown in Fig. 3, the flame-front has zero velocity; at the end it has zero velocity. Hence, it seems that at both ends of the process the maximum pressures would be no greater than the pressure due to the instantaneous combustion of the charge, while, somewhere in between, the detonation pressure should reach a maximum. The actual curve in Fig. 3 is merely a suggestion as to the possible detonation pressures for any position of flame-front when detonation occurs.

An indicator has been developed along the lines suggested a year ago, which gives considerable promise of indicating with fair accuracy the maximum actual pressure attained during the detonation process. It consists of a diaphragm upon which the pressures of combustion and detonation are exerted. Deflection of the diaphragm is imparted to a beam and a mirror by means of knife-edges. The beam is held on the knife-edges by a length of piano wire stretched almost to the elastic limit. A point source of light is directed toward the mirror, which reflects the point of light onto a revolving plate, thus recording the pressure changes. The plate is revolved at a little less than half speed so that about 20 consecutive pressure-rises and pressure-falls are obtained.

Records were obtained when the normal combustion process was taking place, when detonation was beginning to occur, and during rather violent detonation. These records, while preliminary, seem to indicate that there may be a rather close relationship between detonation pressure and flame-front positions. During 1928 it is proposed to continue the theoretical analysis,

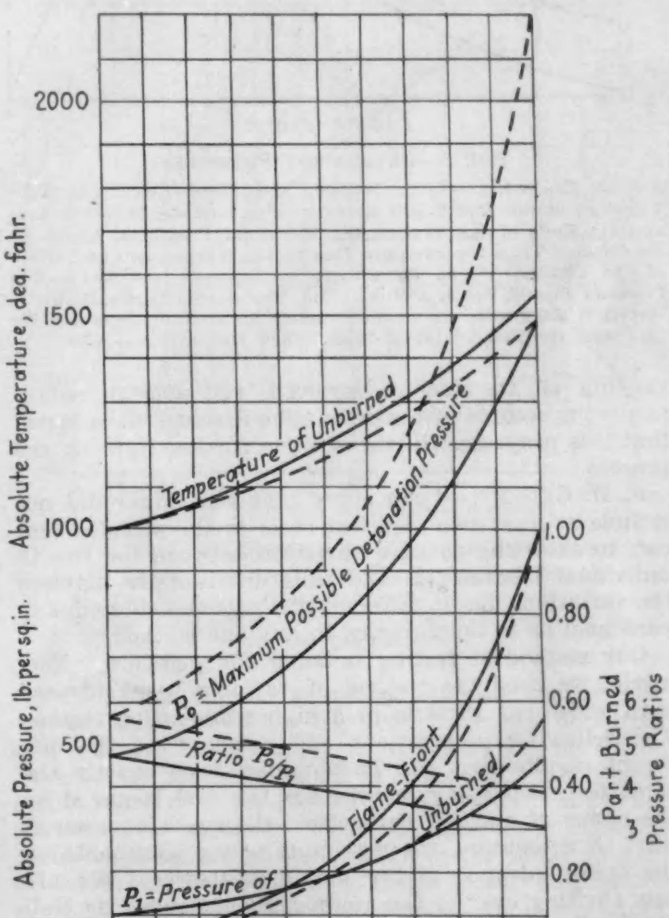


FIG. 2—PRESSURES AND TEMPERATURES FOR THE BURNED AND THE DETONATING PORTIONS OF DIFFERENT FUELS

The Computations Were Made, According to Fig. 1, for Gasoline, Benzene, Carbon Monoxide, and Hydrogen. The Solid Lines Represent the Results from a Mixture of One Part of Hydrogen with 2.39 Parts of Air; the Dashed Lines, Those from a Mixture of One Part of Gasoline with 59.75 Parts of Air. The Maximum Possible Detonation Pressure Is Denoted by P_o, and the Pressure of the Unburned Portion Is Denoted by P_1

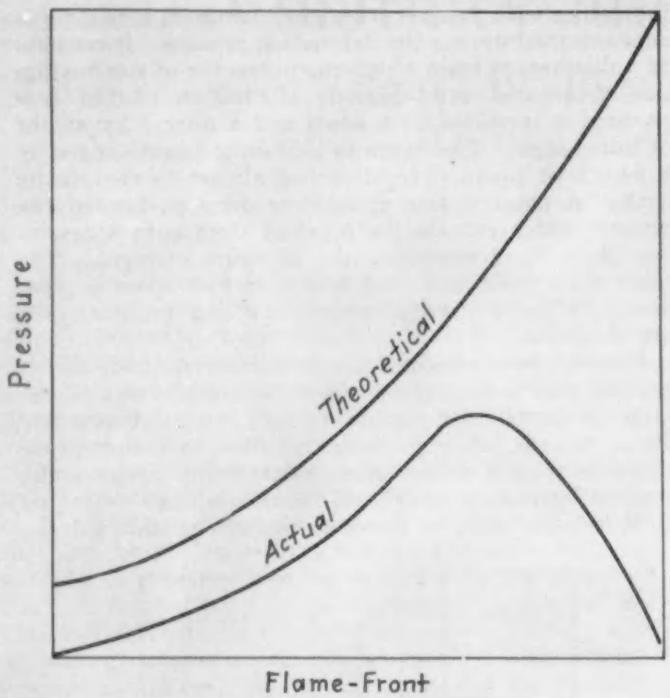


FIG. 3—DETONATION PRESSURES

At the Beginning of the Process, the Flame-Front has Zero Velocity; at the End It has Zero Velocity. Hence, It Seems that at Both Ends of the Process the Maximum Pressures Would Be No Greater Than the Pressure Due to the Instaneous Combustion of the Charge, While, Somewhere in Between, the Detonation Pressure Should Reach a Maximum. The Actual Curve Shown Is Merely a Suggestion as to the Possible Detonation Pressures for any Position of Flame-Front when Detonation Occurs

varying all the factors involved, and also to obtain numerous records of the detonation process. It is hoped that this program will throw some further light on the process.

J. H. GEISSE[20]:—I am sorry that Dr. Edgar did not include at least two identical fuels in the samples sent out, to show the possible variation between the two in individual laboratories and thus differentiate between the variations due to different methods and those due to personnel or to inaccuracies in any one method.

Our method of testing is being changed now. Formerly, we used the method of variable spark-advance with wide-open throttle in a high-compression engine. The following illustrations will demonstrate the different results that can be obtained from exactly the same test, depending on whether the fuel is gaged by the power at start of detonation, the spark advance at start of detonation, the maximum power obtainable, or the spark advance giving maximum power. We are now shifting over to the method recommended by Neil MacCoull; that is, fixed spark-advance and variable throttle. It is interesting to note here that I have not seen Mr. MacCoull for some time, nor had I seen his paper, yet we have come to the same conclusions by entirely different analyses.

Fig. 4 shows one test, made by different methods and by engineers rather inexperienced on this particular job. The curves are drawn through points obtained with various percentages of benzol in domestic aviation gasoline. The short vertical lines intercept these curves at the values obtained for the fuel under test. The top curve shows the manifold vacuum at start of detonation with fixed spark-advance. The bottom curve shows the corresponding power output. The other three curves show results, as designated on the chart, of the test with full throttle and variable spark-advance. These curves and their intercepts show the different values obtained by different ways of testing the same fuel, using the same engineers.

Fig. 5 shows the variations obtained by different methods of interpreting the one run at full throttle with variable spark-advance in a high-compression engine with a compression ratio higher than the test fuel can

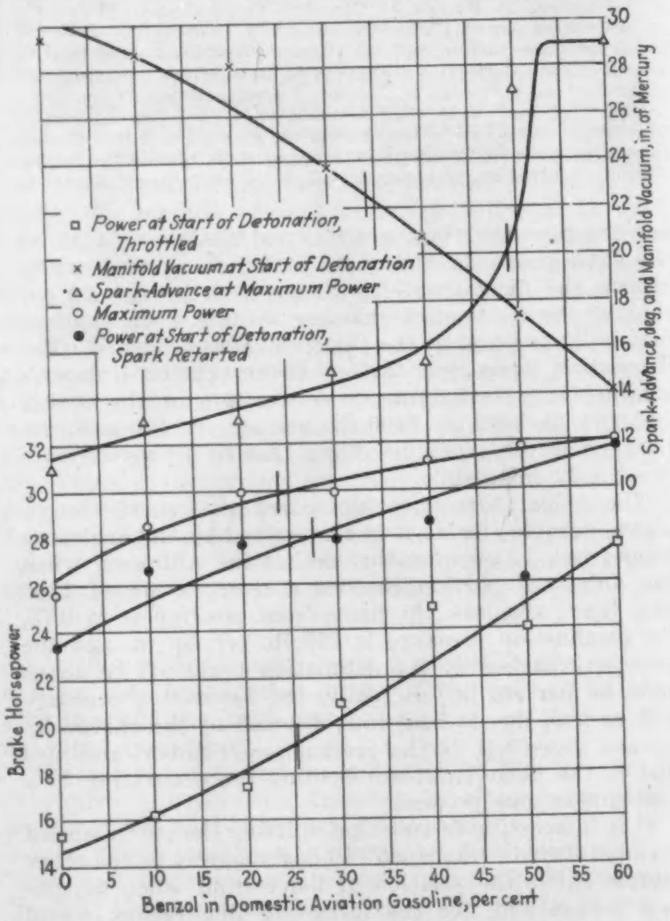


FIG. 4—CURVES FOR FULL THROTTLE WITH VARIABLE SPARK-ADVANCE AND FOR 30-DEG. SPARK-ADVANCE WITH VARIABLE THROTTLE

The Test Was Made by Different Methods and by Rather Inexperienced Engineers. The Curves Are Drawn through Points Obtained with Various Percentages of Benzol in Domestic Aviation Gasoline. The Short Vertical Lines Intercept the Curves at the Values Obtained for the Fuel under Test

withstand. I originally intended Fig. 5 as an indication of the variations due to method, but Mr. MacCoull's paper has rather upset this and I therefore must ascribe the variations to the test engineer.

The curves show the variation in the percentage of benzol equivalent from the average value for each of the four methods of interpretation as indicated on the chart. There were all different kinds of fuels in these tests, ranging from 10-per cent to 50-per cent benzol equivalents. I have plotted the results of each method in a straight line at the end to bring the points together.

[20] S.M.S.A.E.—Chief engineer, aeronautic engine laboratory, Naval Aircraft Factory, Philadelphia.

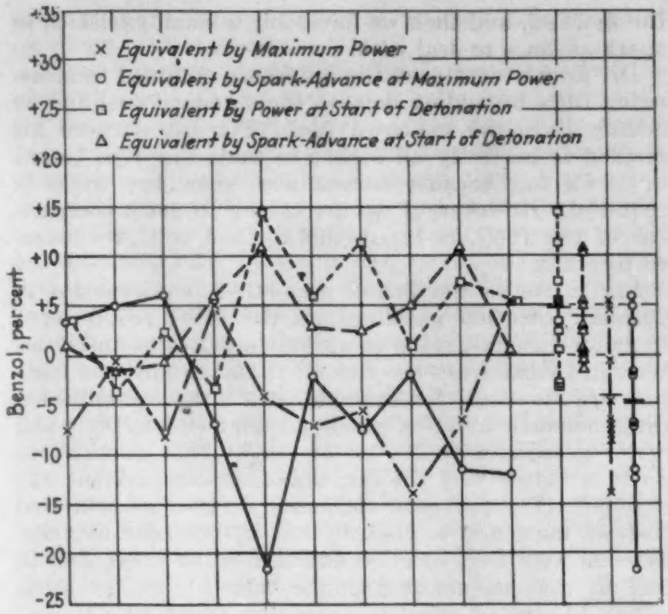


FIG. 5—VARIATION OF BENZOL EQUIVALENT FROM THE AVERAGE

The Variations Are Obtained by Different Methods of Interpreting the One Run at Full Throttle with Variable Spark-Advance in a High-Compression Engine with a Compression Ratio Higher Than the Test Fuel Can Withstand

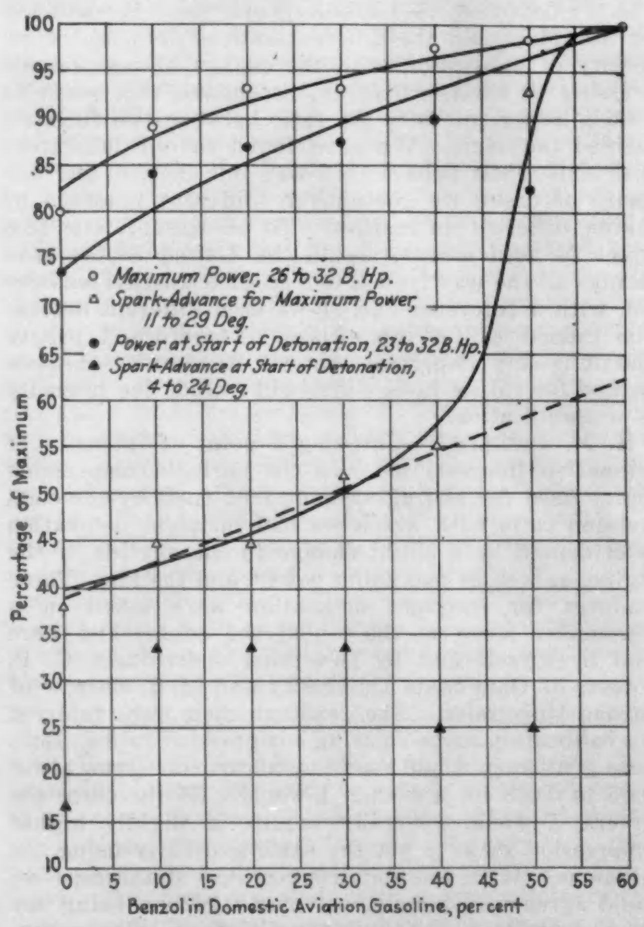


FIG. 6—FULL THROTTLE AND VARIABLE SPARK-ADVANCE

The Upper Curve Shows the Maximum Power Obtainable. A 6.7 to 1 Compression Ratio Was Used. The Respective Temperatures Were, for Carbureter Air, 120 Deg. Fahr.; for Outlet Water, 170 Deg. Fahr.; and for Outlet Oil, 150 Deg. Fahr.

It is somewhat easier to see here the range of results, about where the points fall, and the average values.

The average value that we get for the benzol equivalent if we use the start of detonation seems to be considerably less than the value that we get if we use the maximum power. That may simply be a peculiarity of benzol. The difference is probably due to the difference in rate of increase of detonation, after it has once started, with different fuels. The benzol apparently is a little different from the other fuels in this respect. We cannot say which method is right, but we can see that none of them are very consistent.

Figs. 6 and 7 show the reason we have changed to the manifold-vacuum method. It is entirely different from the standpoint that Mr. MacCoull has. I have shown in Figs. 6 and 7 the variation in percentage of maxi-

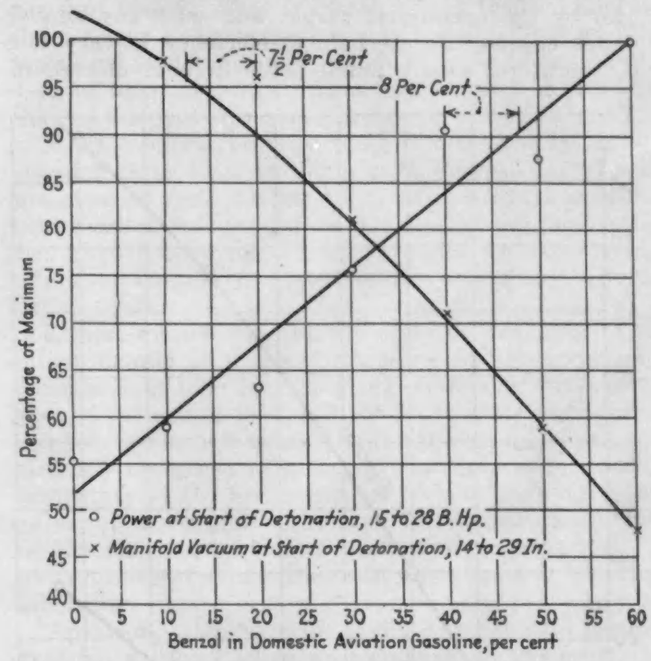


FIG. 7—FIXED SPARK AND VARIABLE THROTTLE

The Spark Advance Was 30 Deg. and the Compression Ratio Was 6.7 to 1. The Respective Temperatures Were, for Carbureter Air, 120 Deg. Fahr.; for Outlet Water, 170 Deg. Fahr.; and for Outlet Oil, 150 Deg. Fahr.

mum reading for various methods plotted against percentage of benzol all the way from 0 per cent to 60 per cent. In Fig. 6, the upper curve shows the maximum power obtainable. It should be noted that it only goes from around 82½ per cent to 100 per cent. That is not a very great variance. The variation is a little bit better with the second curve showing the power at start of detonation, running from about 73 per cent to 100 per cent. The spark advance at maximum power curve, indicated by the open triangles, shows a decided break between 40 per cent and 50 per cent benzol. This, incidentally, shows how far off one can be in using the spark advance if the compression ratio is too near to that suited to one of the fuels. At the lower percentages of benzol, the curve is fairly well defined.

Fig. 7 shows the curves for the type of test advocated by Mr. MacCoull. The open-circle curve shows the power at start of detonation, using a fixed spark-advance and variable throttle-opening. The curve is fairly well defined, but a number of points are off. This was also the case with the curves in Fig. 6, which indi-

cates the possibility of error as the curve is probably correct and the points off the curve are probably wrong. In contrast to the other curves, the manifold-vacuum curve, shown by the crosses, has only two points off and I am sure that this was due to the relatively inexperienced engineer. If he repeated the test, he probably would do a better job.

The manifold-vacuum curve goes all the way from 47½ per cent to 100 per cent for a benzol variation from 0 per cent to 60 per cent. This gives a wide scale. As a matter of fact we are measuring the manifold vacuum in inches of water, and the difference between 0 per cent of benzol and 60 per cent of benzol is 14 in. That gives a little better than 1 in. for 5 per cent of benzol, which is easy to read.

The variation in power is all right in this test, as shown by the open-circle curve; but, with any single-cylinder engine, the mechanical efficiency is very low and, therefore, even a small percentage of change in

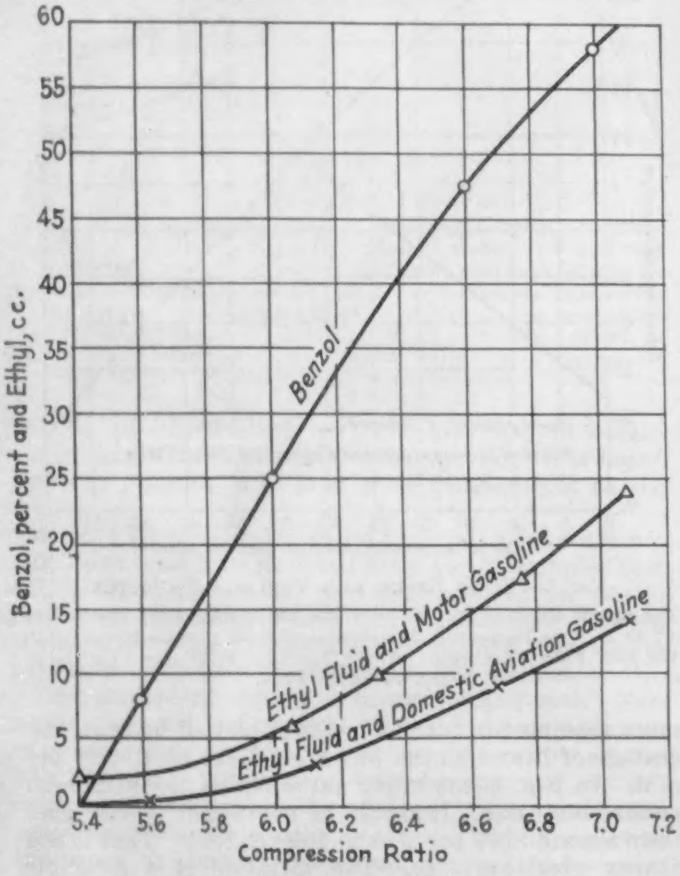


FIG. 8—BENZOL AND ETHYL REQUIREMENTS

The Curves Show the Benzol and Ethyl Requirements in Domestic Aviation Gasoline and the Ethyl Requirement in Motor Gasoline

the friction horsepower makes a considerable percentage of change in the brake horsepower and thereby throws the results out. Some of our tests have shown that 10 deg. off in the oil temperature will throw the results entirely off when gaging by brake horsepower.

If the spark-advance method is used, as in some laboratories, we are more or less limited in the size of the scale. We probably would use a scale no larger than the flywheel, and then we have only a small variation in spark advance to deal with.

Dr. Edgar mentioned the difference obtained in measuring fuels by adding dope to the standard fuel and by adding it to the unknown fuel. For his purpose his method is perfectly all right; he adds the dope to the unknown fuel because he wants to know how much is required. However, if we are trying to get a comparison of two fuels, undoped, this method will give incorrect results.

Fig. 8 shows the benzol and ethyl requirements in domestic aviation gasoline and the ethyl requirement in motor gasoline, using compression ratios as abscissas. We can choose from the two ethyl curves any two fuels that are identical; for example, at a 6 to 1 compression ratio, domestic aviation gasoline with 2 cc. of ethyl; and motor gasoline with 5½ cc. of ethyl. Now suppose we go to a better fuel for our standard comparison; for example, 47½ per cent of benzol. Then we will find that we must add to fuel *A*, that is, domestic aviation gasoline with 2 cc. of ethyl added, 6 cc. of ethyl, and to fuel *B*, that is, motor gasoline with 5½ cc. of ethyl added, 9½ cc. of ethyl to equal our standard. Hence, by using this method, fuels *A* and *B* would differ by 3½ cc., which is a considerable amount; and yet, untreated, they are equivalent.

Readings Affected by Degree of Intensity

J. C. GENIESSE[11]:—Regarding one point brought out by Mr. MacCoull, the different rate of increase of intensity of detonation with the change of compression pressure or throttle opening, he showed that when he used a louder intensity the ratio between two fuels remained the same. We have found in our laboratory that some fuels behave that way but that, in the majority of cases, we got entirely different readings by taking different intensities. To be specific, one fuel which is used extensively in the United States gave ratings all the way from 2 to 8 cc. of tetraethyl lead per gal. with a reference fuel if we used different detonation intensities for comparison. Therefore, I believe that it is very important that we standardize on some method for rating fuels which will include the intensity as a specification.

H. M. JACKLIN[12]:—Choosing a point of intensity of detonation interests me. In the variable-compression engine used for testing we compared fuels by the compression ratio with which we had incipient detonation as evidenced by a slight change in the rhythm of the engine, as well as maximum power, and the like. These readings for incipient detonation were taken on a micrometer screw at the top of the engine and were read by myself and by two other individuals, C. P. Roberts of Ohio State University and M. J. Zucrow of Purdue University. The readings then were referred to a calibration curve showing compression ratios. Both those gentlemen would read the micrometer screw about 0.005 to 0.008 in. less than I would. Of the three observers, I would generally require a slightly higher compression ratio to get the same audibility using the ear alone. With the sonoscope or the stethoscope we would agree very closely, not over 0.002 in. being the greatest variation. I think the difference between myself and the other two observers was due to the fact that I perhaps have my ear drums deadened somewhat from catarrh and from much test work around engines. The stethoscope method eliminated such variables. I

[11] M.S.A.E.—Research chemical engineer, Atlantic Refining Co., Philadelphia, Pa.

[12] M.S.A.E.—Associate professor of automotive engineering Purdue University, West Lafayette, Ind.

think that the incipient point of detonation is the point on which to standardize.

I was interested in Mr. MacCoull's remarks about the air-fuel ratio. After making a half dozen fuel tests, we decided that standardization was absolutely necessary because the fuels were very widely different in viscosity. In one case we required three-quarters as much opening of the needle-valve as in another case to obtain the same air-fuel ratio. Temperature also should be standardized. I should like to see all the experimenters standardize on an air temperature of 100 deg. fahr. at the carbureter inlet. This temperature is just enough above atmospheric temperature so that it is easy to get by a simple means of heating and it can be obtained during any season of the year.

As to the comparison on tetraethyl lead and benzol equivalents, I think the balance is entirely in favor of the benzol method. It is rather difficult, with small samples, to measure out fractional drops of tetraethyl lead to get the exact proportion desired. With the benzol, much larger amounts of the benzol fluid are used and more accurate results can be obtained.

Practical and Theoretical Fuel Rating

Dr. Graham Edgar:—On the subject of air-fuel ratio, I think we must remember we have two points in mind in the rating of fuels. One of these is agreement by different methods in different laboratories. We like to get the best agreement that we can, but we really are measuring the antiknock characteristics of these fuels for use in everyday automobiles at present. The present-day automobile driver does not adjust his air-fuel ratio when he buys a new fuel. He drives up to a pump and, if he used something else before, he asks for benzol and then drives off. He does no adjusting. He ought to adjust the air-fuel ratio for whatever power he wants; but the fact remains that he does not do so.

Some of the fuels that Mr. MacCoull mentioned have a very high viscosity. They agree very well in the air-fuel ratio when it is adjusted to a 13 to 1 mixture; but, if they were compared in an automobile as a driver would compare them, results that would in any way approximate the results gotten in the laboratory at a 13 to 1 ratio would not be obtained. The driver would get a very different mixture ratio in the case of the two fuels. There is something to be said, considering the present custom of automobile drivers, in favor of the use of a fixed carbureter-setting if an experimenter is trying to interpret results in terms of what the automobile driver can expect. Unquestionably, if trying to get theoretical values, some constant air-fuel ratio is a much better basis of comparison. We have two things in mind and I think sometimes not enough consideration has been given to that point.

Standardization of Test Methods

G. G. Brown[13]:—Although I agree absolutely with what Dr. Edgar has said, to obtain consistent results it is necessary that we adopt some standard method of testing. At present, in all the tests I make and report upon, the tests are made in four different ways. Two tests are made with a fixed arbitrary carbureter-setting, one based on incipient detonation and one upon maximum power. The other two tests are made with the carbureter adjusted for the worst knocking of the particular fuel under test, one test based on incipient detonation and the other on maximum power.

Sometimes we get a rather wide range between those tests made with a fixed arbitrary carbureter-setting and those made with the carbureter properly adjusted for the fuel. The only consistent results, and the ones to which I give the most weight, are those obtained with the carbureter properly adjusted for the particular fuel. I think that the first thing we must have is a common language. Mr. MacCoull's paper has made a very valuable contribution in indicating how different results can be correlated if somebody is willing to take the time to interpret into a common language the different hieroglyphics used in reporting antiknock values. There is an idea prevalent in the lay mind that a 20-per cent benzol equivalent fuel is one-half as good as one of 40-per cent benzol. This is of course not true. Likewise, there seems to be a similar notion that a fuel of 2-cc. tetraethyl-lead equivalent is half as good as one having 4 cc. of tetraethyl lead. That may be more nearly true than in the case of benzol values, but still not correct.

If we can interpret all these different scales into a common term such as increase in highest useful compression, or some similar term which bears a straight-line relation to the antiknock value of the fuel, other factors will soon right themselves, if we make a real effort to control our variables, particularly air-fuel ratio.

I think we are clouding the issue by dragging in the minor details at present, when we do not agree on a common language for reporting antiknock values. By way of indicating this we have made some tests for oil companies down through the Southwest and have consistently disagreed with the results reported by another laboratory in the Southwest on fuels of high antiknock value. I was unable to account for it until, finally, one of the men for whom we were making tests took the pains to describe how the tests were made in the other laboratory.

Apparently, their engine is not competent to test any fuels of a benzol value greater than 45 per cent. So, all the fuels which possess benzol values of less than 45 per cent are reported on a benzol scale determined as the percentage by volume of benzol contained in a blend with a straight-run Mid-Continent motor fuel which gives the same antiknock value under tests. As soon as they get a fuel of higher antiknock value, they blend equal parts of the fuel under test with the standard straight-run fuel, which is one which knocks badly, and they find that this 50-50 blend, for example, may have an antiknock value corresponding to a 45-per cent blend of benzol in the standard fuel. Then, reasoning apparently that because 50 per cent of this fuel in the blend is equivalent to 45 per cent of benzol, they give that fuel a benzol value of 90 per cent on the erroneous assumption that a benzol value of 90 is twice as good as a benzol value of 45.

If different laboratories making tests cannot agree closer than that on the language of expressing antiknock value, it seems to me there is no hope of getting concordant results. I am making a plea for a common language by which we may all express antiknock value in the same terms. I suggest increase in highest useful compression ratio, which is used so satisfactorily in Great Britain, or some similar expression which bears a straight-line relation with the antiknock properties of the fuel. Once we can get the laboratories to adopt

[13] M.S.A.E.—Assistant professor of chemical engineering, University of Michigan, Ann Arbor, Mich.

this, the other points will iron themselves out. Until recently we did not know what volatility meant. Now we have perhaps a common language by which we can speak in quantitative terms of volatility, and I believe the whole subject of antiknock testing can be cleared up only after we adopt a common language for antiknock values.

H. L. HORNING[14]:—The fuel division of the research department met recently and discussed subjects in line with Mr. Brown's ideas, one being to try to develop a common language. The research department this year is attempting to devise some satisfactory unit of measurement of detonation and to develop a common language by analyzing all the information.

COORDINATION OF INDUSTRIAL EFFORT

H. M. CRANE[15]:—In the maze of facts and near-facts and alleged facts that we have heard presented this morning, I think possibly we may not realize just what this meeting means. It is hard to believe that 10 years ago there could have existed such a seething condition of recrimination between the oil and the automotive industries as existed at that time. The oil industry complained bitterly that we refrained from even attempting to build engines for the excellent fuel that it provided. The automotive industry replied that the engines were almost perfect and that the oil industry did not know anything about preparing fuels for them. The oil industry seemed to believe that the engineers were not even trying to improve the engine and also expressed a feeling that it was impious to upset the arrangement of the atoms in the fuels as they came out of the ground, even provided any good purpose would be served by so doing. Largely as a result of the work of the Society, ably assisted by some of the oil engineers, a great get-together has taken place since that time. The engineers demanded a fuel suitable for the engines. The oil people have justly remarked to the automotive engineers, "Please tell us what sort of fuel you want that is suitable for the engine you are building." The engine builders had to admit they did not know. Even when by test they found a fuel that was suitable they were unable to specify how that fuel could be duplicated from some other oil field.

The history of the work of the joint fuel committee, composed of members of the American Petroleum Institute and members of the Society, has been a history of an attempt, first, to determine what constitutes a good fuel for the only engine that so far has met all the requirements of universal power, that is, the Otto-cycle engine, and having got some idea of what an all-round good fuel is, have attempted to work out a system in which the quality of various fuels could be determined. The two points in the fuel that seemed to have the greatest bearing on its usefulness were the volatility and the antiknock value. The work on volatility covered a period of years to determine what volatility really represented and under what conditions. While that work was going on, however, an equally great amount of work was being done in an attempt to find some simple unit of measurement for determining volatility in terms of what the engine considered volatility. The paper by Mr. Bridgeman shows that we are getting to the end of that research after a painstaking investigation by a great number of very able men, although there is still work to be done. We have not yet reached the stage in which a garage man or an individual owner can determine whether he is getting suitable volatility, but at least we have gone a long way along the road.

With the increasing competition in fuel after the war and with the introduction of tetraethyl lead as an antiknock possibility, great interest began to be focused on the antiknock value of fuels. The increase in aviation had much to do with that, due to the tremendous pressure it brought to bear on increasing the power output of individual engines per pound of weight. The oil industry, stimulated by the demand, has gone from one point to another in attempting to improve antiknock value and to find out more about it. Again we have come up against the fact that we have no easy way of determining in advance what an individual motor-car will think is a good antiknock fuel for its own particular use. Two years of very hard work already have been devoted to this research, and the papers presented here summarize the results of that work. Obviously, we still have much to accomplish before we can say that the work is finished. But, with the number of able men who are now engaged in the work, backed by tremendous financial and other resources, I have no doubt that the complete solution will be attained. It certainly will be expedited if a common language can be developed.

W. E. LAY[16]:—Regarding the development of a common language, what we are trying to do is to use an engine and a fuel to accomplish better results from the combination. One thing we want to do is to increase the power of a given engine. We want to do that and still use less fuel, and we want to do it in a way so that the fuel will not detonate. To devise a unit of measurement that can be used by both the petroleum and the automotive engineers, they must work together from the standpoint of the engineer. Perhaps the increase in compression ratio might be the most acceptable unit of measurement, but we should not be in too great a hurry about deciding. Let us first be sure that we have devised a unit by which we can abide.

STANDARDIZING THE AIR-FUEL RATIO

A. LUDLOW CLAYDEN[17]:—I shall comment upon only one point in Dr. Edgar's paper, that is, the standardizing of a method to be used for air-fuel ratio. The level in a carbureter jet will depend upon the specific gravity of the fuel. If different fuels are used in an actual automobile the air-fuel ratio will, therefore, differ, and it seems probable that in laboratory testing results most closely corresponding to those obtainable on the road will be secured by using the same carbureter without change of adjustment for the series of fuels to be tested. This appears to me to be, at present, the most satisfactory method for what might be called commercial testing.

For research work, apart from commercial testing, the method followed necessarily would depend upon the precise matters being studied, and it appears to me that there is no advantage in attempting to standardize procedure for work of this kind. For commercial testing, however, it would be helpful if nearly the same

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[15] M.S.A.E.—Technical assistant to president, General Motors Corporation, New York City.

[16] M.S.A.E.—Associate professor of mechanical engineering, University of Michigan, Ann Arbor, Mich.

[17] M.S.A.E.—Research engineer, Sun Oil Co., Philadelphia.

practice were followed in different laboratories, and I believe a good deal is to be said in favor of a single, simple carbureter. The two constant-level cups devised by the Ethyl Gasoline Corporation give most excellent results, but are always subject to a possible error in adjustment and, if not checked sufficiently, accidental errors of considerable magnitude often might easily be introduced.

Concerning the new form of bouncing-pin, which I believe was developed by Mr. Boyd, in which a small diaphragm replaces the piston and spring, experience of some 6 weeks' use of this type of pin has convinced me that it is a very great improvement upon the old design, since it is entirely unaffected by dirt and it completely eliminates both leakage and wear. Undoubtedly, with the old design of pin, ratings obtained did to some extent depend upon the mechanical condition of the instrument. It is, of course, possible that there will be some difficulty in standardizing the diaphragm for the new type of pin, but that appears to me a much more simple problem than standardizing and maintaining in service the fits and spring tensions of the old type of pin. I think Mr. Boyd is to be congratulated for this accomplishment.

Specification of Anti-Detonant Qualities

Hon. Edward P. Warner[18]:—Like everyone else in any way connected with aviation, I feel a tremendous interest in the results of these studies. It is perfectly clear to all of us now that one very promising way to improve engine performance is the provision of better fuel to be universally available upon flying fields, for it is futile to provide the most perfect of products in the laboratory unless the operator can be assured of finding it wherever he goes. Not until then does it become practicable to design engines for its use. It is even more apparent that a necessary preliminary to the general availability of such a fuel is the development of means of specifying anti-detonant qualities clearly, tangibly and positively.

At first sight, Figs. 1 and 4 in Dr. Edgar's paper are somewhat disheartening, showing results for two of the test fuels sprinkled seemingly almost at random. Statistical analysis changes the picture, for it is the extreme divergences and not the average run among a number of curves that catches the eye. Of the 12 sets of results compared by Dr. Edgar, three give results notably far from the average, and in one of these three cases the engine used had a compression ratio so low as to make it very dubious as an instrument for the measuring of detonation. The remaining nine sets of tests cling together with excellent consistency. The mean deviation of all the results for those nine from the averages for the several fuels taken separately is only 0.17 cc. of tetraethyl lead, and five of the nine show an average departure from the mean of 0.16 or less. As the five included representatives of three very distinct methods, the bouncing-pin comparison, a road test in a car, and comparison in a variable-compression engine, an indication that numerous laboratories are now capable of using divers methods of giving so nearly the same results that their probable error in measuring antiknock properties is less than the effect produced by adding 0.2 cc. of tetraethyl lead can only be regarded as most encouraging from the point of view of those desirous of an early adoption of explicit specification of antiknock quality directly measured.

[18] M.S.A.E.—Assistant Secretary of the Navy for Aeronautics, City of Washington.

[19] A.S.A.E.—Sales engineer, Ensign Carburetor Co., Los Angeles.

Agreement of Results

J. B. Hill[19]:—In Dr. Edgar's classification of the methods used for determining the amount of tetraethyl lead necessary to equate the four samples to sample 5J he has set up two classes of "dynamometer methods" compared in his Tables 6 and 7, the one class being based on throttle opening or power and the other class on spark advance. As a matter of fact this is really a distinction without a difference since at the point of measurement the throttle or power is the same for all samples in the first case and the spark advance the same for all samples in the second case. These two "variables" are therefore just as completely fixed in their measurements as they are in the case of the bouncing-pin methods. The only true basis of this classification appears to be that the bouncing-pin is the indicator of detonation in the method compared in Table 4; whereas, the ear is the indicator in Tables 6 and 7. The Bureau of Standards results included in Table 6 offer a third indicator; namely, the actual drop in the power curves.

Dr. Edgar has emphasized the importance of air-fuel ratio and we are in entire agreement with him on this. If we reclassify the various results obtained in accordance with his four methods of setting air-fuel ratio, we find that they fall as follows:

(1) Constant air-fuel ratio
  - Ethyl Gasoline Corporation, Series No. 1
  - Standard Oil Co. of Indiana

(2) Constant float-level
  - Armour Institute of Technology, both Series
  - Atlantic Refining Co.
  - Ethyl Gasoline Corporation, Series No. 2
  - Standard Oil Co. of New Jersey
  - University of Michigan

TABLE 1—CONSTANT FLOAT-LEVEL METHODS

	Armour Institute of Technology, 4.58 Compression Ratio	Armour Institute of Technology, 5.80 Compression Ratio	Atlantic Refining Co.	Ethyl Gasoline Corporation, Second Series	Standard Oil Co. of New Jersey	University of Michigan
Fuel Ratio for One Fuel	13 to 1	13 to 1	12.5 to 1	12 to 1	13.5 to 1	
Indicator	Ear	Ear	Ear	Bouncing-Pin	Bouncing-Pin	Power
Results, Sample No.						
1J	3.05	3.40	3.0	3.50	3.7	3.4
2J	2.40	1.89	1.5	1.35	1.4	1.9
3J	0.57	0.79	0.5	0.35	0.6	0.8
1J	2.50	0.94	1.0	0.85	1.4	1.7

(3) Maximum detonation
General Motors Corporation, both Series

(4) Maximum Power
Bureau of Standards

The second class is the only one including enough methods for comparison; see Table 1. The low-compression-ratio series of the Armour Institute of Technology show wide differences from the others, possibly on account of the very high spark advance necessary to produce detonation. With the exception of this series, however, and the 1J-sample result of the Atlantic Refining Co., the results on samples 1J, 2J and 3J show fairly good agreement. The results on the benzol blend, sample 4J, are more erratic; but, as Dr. Edgar has pointed out, the benzol blends are subject to greater differences with changes in mixture ratio.

Calibration on Compression Basis

CHARLES O. GUERNSEY[20]:—Commenting on the papers by Mr. Cummings and Mr. MacCoull, it is obvious that these gentlemen are striving to arrive at a common standard for measuring and listing detonation characteristics. It is equally obvious that such a result is highly to be desired as a supplement to specifications covering other characteristics, all of which are fairly well covered at the present time. I can only add that a definite specification along this line will be of invaluable assistance in assuring correct fuel to meet existing conditions.

It is impossible for a designer at present to design any engine, particularly one intended for heavy duty, in such a way as to be most suitable for the various fuels. If compression ratios are high enough to give the desired power on fuels having good knock characteristics, excessive detonation follows on fuels having poorer characteristics. I realize that this is no new thought and that this confusion has led these authorities to do the work that they have undertaken. My only purpose is to add the weight of one more voice to the request for early standardization along this line. I prefer the method whereby fuels are calibrated on the basis of the amount of compression which they will withstand in a given designated type of engine without detonation.

Standardization in Terms of the Fuel

A. L. BEALL[21]:—Mr. MacCoull's paper represents a vast amount of work. He has secured a relation between results as reported by various laboratories by shrewd calculation of the effect of different methods. Obviously, this process is too complicated for daily use and its accuracy is dependent on the skill of the calculator and the soundness of his reasoning.

The paper mentions a method of securing results in a medium suitable for an interchange of antiknock values which recommends itself by its simplicity. I refer to a standardized reference fuel or, better still, the normal hydrocarbons as suggested by Dr. Graham Edgar. Differences in knock values of any two fuels will be the same on any one engine when run immediately following each other and under the same conditions. Under any given set of conditions, so long as they are identical for both fuels, results show a similar difference. Results reported in terms of a standard fuel can be identified readily by the recipient in terms of his own method of reporting.

It seems to me more important to standardize in terms of the fuel, allowing all investigators full latitude in the means of securing results rather than to attempt to limit a small fraction of the many mechanical variables. After all, these results are not an end in themselves, and their usefulness is dependent on their use for two purposes. One is to enable the automotive engineer to determine the fuel limitations of his engine. The other is to enable the refiner to determine that his fuel is suitable for engines in the field in which he markets. Ideally, we should know and report the highest useful compression ratio for the engine with respect to available fuels, and the fuel with respect to its limit of compression pressure without detonation. Obviously, the variations in combustion-chamber design of cars in the street will prevent large use of such a method of reporting, though our test engines be never so well standardized. The use of a standard reference fuel will enable the automotive engineer to determine the limit for compression ratio with his design of combustion-chamber and, after all, this is what he wants to know. I feel, therefore, that a standard reference fuel offers the best practical solution of the problem for the immediate future.

[20] M.S.A.E.—Chief engineer, automotive car division, J. G. Brill Co., Philadelphia.

[21] A.S.A.E.—Refined oil department, Vacuum Oil Co., New York City.

The Faith of the Fathers

IT would be well if there were a wider knowledge of the function of the college. Education is mental enlargement. Its possibilities of development are in awakened minds. The ultimate purpose of the college is aroused thoughtfulness; that is, the cultivation and expansion of the minds of its students to the limits of their possibilities in the realms of abstract thinking, and the application of these abstractions to solving problems of our social adjustments in our common life.

The greatest problem of our time is how we are to adjust ourselves with the necessary promptness to the rapidly changing conditions of life. The success of American industrial life more than upon any other principle has been founded on the flexibility of the American business-man's mind, by which he has been willing to demolish his factory, to junk his mechanical equipment, or to redevise his complicated processes of manufacture, when by so doing he could replace these more efficiently. Yet the analogy seems to be lost upon us when one attempts to persuade us to apply the principle to social usages, political organization, educational procedures, or religious objectives. At once appeal is made for holding to the faith of the fathers. All of the forces of censorship, repression, and prohibition are set in motion to preserve the theory that "whatever is" is better than anything that might conceivably be.

The usefulness to society of the college will eventually be reckoned on the basis of the preparation given to men of a given era to live their lives understandingly of conditions about them, and serviceably to society.—President Hopkins, of Dartmouth College, in *Scribner's Magazine*.

Present Tendencies in Motor-Fuel Quality

By George Granger Brown[1]

Buffalo Section Paper

WE are entering a period in which the refiner is making a conscientious effort to give his fuel high antiknock value and such effective volatility that it will give superior performance in any automobile engine in which it is used. The present tendency is away from the misleading values such as color and gravity.

Ease of starting and good acceleration, particularly of a cold engine, demand high partial volatility even more than antiknock value, while the development of maximum power and a high fuel efficiency in modern engines supplying a large amount of heat to the mixture demand a relatively high end-point in the distillation test.

The author discusses the difficulties of using fuels possessing these characteristics in such engines, and indicates the desirability of the automotive and the oil industries cooperating in finding a solution of their joint problem of suiting the engines and the fuels to each other. The oil industry is now investigating the relation of vapor pressure, volatility, dew-point and similar fuel characteristics to engine performance, and we may expect within a short time to know what are the proper specifications for motor fuel to be used in engines that supply a large amount of heat to the intake manifold.

Various methods of improving motor-car performance, as by increasing the engine speed, the compression ratio, or the rear-axle ratio, and the effect these have of increasing the fuel consumption, are considered, and the conclusion is drawn that any further improvement must be based upon an increase in compression ratio.

Finally, comparison is made of the per-mile cost of using premium fuels and ordinary gasoline in engines of different compression-ratios. It is shown that there is no economic advantage in buying antiknock fuels at a 3-cent premium, which now corresponds to about 15 or 16 per cent of the selling price, if an engine having a compression ratio of 5.5 to 1 can be operated satisfactorily on ordinary gasoline.

SINCE the automotive industry created the market for gasoline by converting gasoline from a waste product, of which the refiner was glad to be rid at any price, to a valuable product, we have passed through the period of apparent shortage of motor fuel. During that period the refiner was producing almost any fuel he saw fit and compelling the motor-car manufacturer to make special arrangements so that the engine could operate on the low-volatility fuel in a fairly satisfactory way. We are now entering a period in which the refiner of motor fuel is making conscientious effort to give his fuel high antiknock value and such effective volatility that it will give superior performance in any automobile engine in which it is used. During this time interval of about a quarter century, we have seen the criteria for superior gasoline change from high gravity through color, odor, "doctor sweet," and low end-point to antiknock value and effective volatility or, if we may use the term, "performability."

The present tendency in motor fuel is away from the misleading values such as color and gravity, and toward placing emphasis upon the properties of the fuel which influence the performance that fuels can give in a motor-vehicle; namely, antiknock value and effective volatility.

This emphasis upon anti-knock value particularly has been brought about largely by educational advertising carried on intensively by a company expecting to profit directly by the results of the campaign. Because of the intensity of the advertising, we find that antiknock value is regarded popularly as the one outstanding property of motor fuel. Perhaps this is not so much an over-emphasis of antiknock value as it is an underemphasis of other properties of motor fuel that have an equal, or at times even greater, influence upon performance.

Ease of starting and satisfactory acceleration, particularly of a cold engine, demand high partial volatility in a fuel even more than antiknock value. Also, the development of maximum power and a high fuel efficiency in modern engines supplying a large amount of heat to the mixture because designed for 1920 to 1922 gasoline, demands a relatively high end-point in the American Society for Testing Materials distillation, as well as antiknock value. For these reasons it seems that the popular demand for low-end-point fuel is based largely upon the idea that low end-points must give good acceleration and general performance because the old pre-war gasoline which gave better acceleration had a low end-point; for investigation shows that high *partial* volatility, or low 40 to 60-per cent points, is responsible for good acceleration, and not low end-points, which may have the opposite effect.

It seems likely that the motor fuel for the immediate future will be marketed upon the basis of performability and that those characteristics which indicate superior engine performance will be the characteristics demanded. Gasoline will be sold upon its merits as a motor fuel even more than motor-cars will be sold upon their merits as a means of transport, because the latter must possess style to satisfy the increasing number of women buyers, whereas fuel is placed in the tank and consumed without being seen.

During recent months, with the intense interest in high-compression engines and motor fuels of high antiknock value, the advertising carried by some of the

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motor-car manufacturers featured simply the one characteristic of their cars that they had a high-compression engine. Similarly, the advertising carried by some of the refiners and marketers of petroleum products emphasized that their fuels had high antiknock value. In the more recent advertisements we find that emphasis is placed more upon general performance than merely upon high compression and high antiknock value.

Characteristics Indicating Superior Performance

Exactly what characteristics indicate superior performance is a rather long story. The indication is definite that the burden carried by the automotive industry is being transferred to the oil industry. No longer is it required of the automotive engineers to build an engine to utilize any fuel that might be produced; it is now the burden of the refiner to produce a fuel that can be used satisfactorily in any motor-car that might be produced.

We expect the automotive engineer to design engines with due regard to the properties of motor fuels that are available at the time the motor-car is to be used. Many engineers readily admit that there is as much opportunity for improvement in the engine as there is in the fuel, particularly as regards the knocking tendency. Careful investigation has shown that the compression ratio of a typical engine can be increased as much as 25 to 35 per cent without increasing the tendency to detonate, provided the shape of the combustion chamber is so improved as to decrease the relative tendency of the combustion chamber to cause detonation. As an increase in benzol value from zero to 45 allows about a 20-per cent increase in the compression ratio, it is obvious that the automotive engineer cannot place the entire burden of eliminating the knock in high-compression engines upon the petroleum industry or upon the characteristics of the fuel.

On the other hand, it is extremely difficult if not impossible at present to supply sufficient heat to the fuel or to the carbureter for starting in cold weather if the fuel does not possess proper partial volatility for starting without the application of extra or external heat. The most hopeful prospect for starting automobiles on fuels that possess low partial volatility seems to be the injecting of liquid fuel into the explosion chamber rather than depending upon the drawing of an explosive mixture up the intake manifold and through the intake valve in the usual way.

An even more serious difficulty is presented in driving a cold engine after it has been started if the fuel does not possess the proper partial volatility for forming an explosive mixture. Under these conditions it is obviously impossible, without changing the entire design and operation of the engine, to inject liquid fuel into the combustion chamber. Dependence must, then, be placed entirely upon drawing an explosive mixture from the carbureter through the intake manifold into the cylinders.

After the engine has become warmed, it is of course possible to apply sufficient exhaust heat to the intake manifold so that relatively satisfactory engine performance can be obtained when using fuels that are considerably less volatile even than the minimum specified by the United States Motor Fuel Specifications. However, if an engine is designed to operate on these fuels of extremely low volatility by supplying a large amount of heat to the intake manifold and carbureter, good grades of fuel of sufficient partial volatility for satisfactory starting and acceleration of the engine as now designed cannot be used satisfactorily. The fuel becomes superheated in the carbureter because of the large amount of heat supplied to the carbureter and actually vaporizes in the carbureter before passing through the jet. As the carbureter jet is designed to meter a liquid and not a gas, when the fuel vaporizes before passing the jet an extremely lean mixture is supplied which will not burn in the cylinders. This causes the engine to run irregularly and to miss explosions, and in severe cases actually prevents operation of the engine in any way.

Many automobile manufacturers were so impressed with the low volatility of motor fuel as marketed in this Country during the years of 1920 to 1923 that they still persist in heating the intake manifold and the carbureter to extremely high temperature, so that a fuel possessing satisfactory volatility for starting and acceleration frequently causes trouble in the automobiles having these engines.

Refiners Recognize Importance of Partial Volatility

Refiners now recognize the importance of partial volatility and many of them are actually producing fuels that give easy starting and good acceleration of engines such as were available even before the World War. Recent surveys of motor fuel marketed throughout the Country clearly indicate the present tendency to supply fuels of this nature. We have measured gasoline temperatures as high as 178 deg. fahr. in the bowl and fuel ducts of the carbureter on an engine under actual conditions of road tests. It seems obvious that fuels giving easy starting and having an initial boiling-point on the A.S.T.M. distillation of about 95 deg. fahr. will vaporize in the carbureter if the fuel is heated to temperatures much over 150 deg. fahr.

Even if the fuel does not possess a high vapor-pressure or tendency to form vapor, but does have a rather low dew-point or equilibrium dry-point as indicated by a low 90-per cent point on the A.S.T.M. distillation, another difficulty is experienced when it is used in engines that supply a large amount of heat to the intake manifold. Such a fuel seems to form a dry mixture at a relatively low temperature, 100 to 120 deg. fahr., and the additional heat supplied by the exhaust-jacketing of the manifold serves simply to superheat the mixture in the intake manifold. This causes a loss in power and an increase in fuel consumption, particularly at part-throttle, because it serves no useful purpose in improving distribution but decreases the volumetric efficiency of the engine.

Hot Manifolds Increase Knocking

The heating of the charge as it passes through the intake manifold introduces another difficulty. It increases the tendency of the mixture to detonate in the explosion chamber. Apparently this tendency is caused both by the increased temperature of the mixture and by the better distribution obtained if the mixture is reasonably dry. The mixture which detonates worst is the best mixture for maximum power with good fuel-economy. Accordingly, if the mixture is not heated so as to be substantially dry, we find uneven distribution to the different cylinders actually decreasing the tendency of the fuel to detonate. One cylinder will receive a slightly rich mixture while another cylinder will

receive a slightly lean mixture. As mixtures both richer and leaner than the ideal mixture show less tendency to detonate, it is obvious that such conditions tend to decrease the knocking tendency of the fuel when used in an engine that does not heat the charge to a high temperature.

Uniform Fuels versus Uniform Engines

At various times we hear statements that it would be very desirable if all of the fuels sold throughout the Country were absolutely uniform so that the automotive engineer could design his engine to operate satisfactorily on a uniform fuel with reasonable assurance that such a fuel would be generally available. This seems to me to be a reasonable request but, for some reasons, rather a difficult undertaking for the oil industry. On the other hand, it seems to me to be equally reasonable for the oil industry to request that the automotive engineers adopt one uniform type of engine having about the same degree of heating on the manifold so that the oil industry can market one uniform fuel on which all automobiles will give the proper performance. So far, the two industries have not succeeded in meeting on a common ground in supplying either the uniform fuel or uniform engines. Perhaps it is highly desirable, however, in the interest of progress, that no standard fuel and no standard engine be adopted.

In any case, it seems necessary that motor fuels should possess the characteristics of sufficient volatility to start and to operate those cars which supply the least amount of heat to the mixture and a dew-point sufficiently low not to produce an extremely wet mixture. On the other hand, these fuels must not possess such a high tendency to vaporize as to cause gassing in the carbureters nor a dew-point so low as to allow the formation of superheated mixtures on those engines which supply a large amount of heat to the manifold or carbureter. The difficulty of meeting these specifications is largely that we do not know exactly what the specification should be. The oil industry is now investigating carefully the relationship of vapor pressure, volatility, dew-point and similar characteristics to engine performance, and we should expect within a short time to know what are the proper specifications for motor fuels to be used in engines which supply a certain amount of heat to the intake manifold. Perhaps, after this information is readily available, it will be possible for the automobile and the oil industries to agree on specifications for manifold heating and motor-fuel characteristics.

Methods of Increasing Car Performance

The performance of a motor-car can be improved by increasing the compression ratio of the engine or, without change in compression ratio, by increasing the piston displacement per revolution of the driving wheel, that is, by either increasing the speed at which the engine operates for a given car speed or increasing the piston displacement of the engine without changing the rear-axle gear-ratio.

The former method of increasing displacement is widely used in England, largely because taxes on motor-vehicles are based upon the size of the bore. In this Country both methods have been used, depending upon the policy of the manufacturer. The former method is more economical for the manufacturer because it does not involve retooling his factory for producing an engine of a larger bore. It means simply different valve timing and relatively minor changes in the construction of his engine. However, a point is soon reached where the increased speed of the engine introduces difficulties in lubrication and losses resulting from increased friction and wear of the moving parts. So it is very doubtful if the manufacturers will appreciably increase the engine speeds above the high speeds now in use.

A very suggestive article by W. S. James[3] brings out the relative advantages and disadvantages inherent in these different methods of increasing the engine displacement.

Each of these methods of increasing motor-car performance invariably increases the fuel consumption. With the increased piston displacement, a greater volume of explosive mixture must be fed to the engine for each revolution of the rear wheels. On the other hand, an increase in the compression ratio increases the engine power and the car performance and also increases the efficiency of the engine, or the miles obtained per gallon of fuel. For this reason it is clear why so much emphasis has been placed by the automotive engineers upon an increase in compression ratio.

Comparison of Fuel Consumption

It may be of interest, however, to compare the relative increase in fuel consumption or decrease in mileage effected by an increase in the rear-axle ratio or in piston displacement sufficient to give the same increase in performance as a specified increase in the compression ratio. Using for the basis of comparison the data reported by Mr. James, which are based upon an engine having a piston displacement of 100 cu. in., a rear-axle ratio of 3 to 1, a compression ratio of 4 to 1, and a car weight of 3500 lb., and which are found to agree closely, as regards changes in compression ratio, with similar data reported by Ricardo, we find:

(1) An increase in compression ratio of 20 per cent, that is, from 4 to 4.8 to 1, results in an increase in mileage of about 14 per cent, accompanied by an increase in performance at 20 m.p.h. that can be equaled without change in compression ratio only by increasing the rear-axle ratio about 12 per cent, with a corresponding decrease in mileage of about 9 per cent, or by increasing the piston displacement with a constant rear-axle ratio by about 9 per cent, which results in a decrease in mileage of about 4 per cent. Adding the decrease in mileage effected by an increase in rear-axle ratio, or by an increase in piston displacement, to the increase in mileage effected by an increase in compression ratio, we find that we can produce an automobile having the same performance as that obtained by a 20-per cent increase in compression ratio, without change in the compression ratio but with a decrease of about 23.5 per cent in mileage compared with that obtainable with the engine of high compression if the improved performance is the result of an increase in the rear-axle ratio, or a corresponding decrease in mileage of 16 per cent if the improved performance is the result of increasing the piston displacement without changing the rear-axle ratio.

(2) If the compression ratio is increased 20 per cent, from 5 to 6 to 1, the mileage is increased about

[3] See The Journal, January, 1928, p. 96.

10 per cent, with an improvement in performance that can be obtained without change in compression ratio only by a sacrifice of about 6.75 per cent in mileage if the rear-axle ratio is increased, or by a sacrifice of about 4.2 per cent in mileage if the piston displacement is increased without changing the rear-axle ratio. Adding these losses in mileage to the increase in mileage effected by an increase in compression ratio from 5 to 6, we find on the same basis that the mileage is decreased by about 19 per cent if the improved performance is obtained by an increase in rear-axle ratio, or 13 per cent if the improved performance is obtained by an increase in piston displacement without altering the rear-axle ratio.

(3) If the compression ratio is further increased from 6 to 7 to 1, we find that the mileage is increased about 7 per cent and that the improved performance can be equaled without change in compression ratio only by a corresponding decrease in mileage based on that obtained from the 7-to-1 compression-ratio engine of about 11 per cent by increasing the rear-axle ratio, or about 8.5 per cent by increasing the piston displacement.

Because an increase in compression ratio improves the mileage, and at the same time increases the car performance, it is necessary, if we are to obtain the same performance by an increase in rear-axle ratio, to tolerate a relative decrease in mileage of 24 per cent if the improved performance is obtained by increasing the compression ratio from 4 to 4.8 to 1, or we may effect the same improvement in performance by increasing the piston displacement without altering the axle ratio, thereby losing only about 16 per cent in mileage.

Factors Underlying Methods of Improvement

Most of the improvements in car performance have been obtained by increasing the axle ratio rather than by increasing the piston displacement while retaining the same rear-axle ratio. It seems now that, with rear-axle ratios frequently as high as 5 to 1, the practical maximum improvement in car performance that can be obtained by that means has been reached. Any further improvement must be based upon an increase either in compression ratio or in piston displacement.

Here again the same forces apply, as it is obviously much simpler and more economical for the manufacturer to increase the compression ratio of his engine than to build a larger engine. An increase in compression ratio further increases the mileage, while an increase in the piston displacement to obtain the same relative improvement in performance causes a decrease in the mileage.

Let us assume, however, that the improvement in performance could be brought about by an increase in piston displacement, and compare the cost when using the ordinary gasoline in an automobile having greater piston displacement with the cost when using a premium gasoline of high antiknock value in a car having an engine of higher compression-ratio. We shall assume for ordinary gasoline a benzol value of zero, which represents the low limit of ordinary gasoline now on the market, and a benzol value of 45 for the premium antiknock fuel. Few fuels now on the market show a benzol value greater than 45, and most of the premium antiknock fuels show a benzol value of about 40 to 45; so we are making a fair allowance for possible increase in compression ratio through the use of premium fuels.

As a benzol value of 45 allows an increase in the compression ratio of about 20 per cent over that allowed by a fuel possessing zero benzol value, it is seen that, if the engine is designed so that it can operate only on a 4-to-1 compression ratio with ordinary gasoline, we can afford to pay a 19-per cent premium for a fuel possessing an antiknock value of 45 benzol if the gasoline sold at the posted price possesses zero benzol value.

If, however, the engines are designed so that they can utilize the ordinary gasoline of zero benzol value at a compression ratio of 5 to 1, we can afford to pay a premium of only 15 per cent for a motor fuel having a benzol value of 45. If the efficiency of the engine is so increased by better designing that with a compression ratio of 6 to 1 the engine can operate satisfactorily on the ordinary gasoline of zero benzol value, we can afford to pay little more than 9-per cent premium for a motor fuel possessing benzol value of approximately 45.

Ordinary gasoline now sold at the posted price frequently possesses a benzol value of more than 20, and in some places of more than 30. As a benzol value of 20 indicates an increase of about 5 per cent in the highest useful compression-ratio, it is seen that the premium antiknock fuels possessing a benzol value of about 45 do not allow an increase in the highest useful compression-ratio of much more than 15 per cent as compared with the average motor fuel now obtainable at the regular price.

When Is Premium Fuel Economical?

We are now paying for antiknock fuels a 3-cent premium, which corresponds to about 15 per cent premium based on the present selling price of ordinary United States motor fuel. The foregoing calculations suggest, then, that there is an economical advantage in purchasing high-antiknock fuels at this premium only if the engine design allows the use of a compression ratio not exceeding about 4.8 to 1 when using a fuel of zero benzol value.

As the ordinary United States motor fuel now on the market exceeds zero benzol value in antiknock properties and we now have available in standard quantity production engines of 5.5-to-1 compression ratio which can be operated on ordinary gasoline, it seems that the industry has about reached a condition of economic balance in which there is neither economic gain nor loss in paying 3 cents premium, about 15 to 16 per cent of the posted price, for antiknock fuels to be used in engines having compression ratios greater than 5.5 to 1. If the price of gasoline goes up appreciably so that the 3-cent premium represents a smaller percentage in the total purchase price, or if the engines become less efficient, there may then be greater economic advantage in the use of fuels of high antiknock value in high-compression engines. It seems more reasonable to expect, however, that the efficiency of the combustion chamber of the engines will be increased by design rather than decreased, so that it will be necessary for the selling price of gasoline to increase appreciably merely to maintain the economic balance between the increased cost of using fuels of high antiknock value in high-compression engines and the decreased mileage obtained with engines of greater displacement.

The public must pay a premium somewhere for increased performance, either to the fuel producer for a high-antiknock fuel that can be used in high-compres-

sion engines or for greater fuel consumption in engines of greater displacement, or to the motor-car manufacturer for the expense of changing factory equipment to produce engines of larger bore and greater piston displacement, unless engines of improved design are made available which can be operated satisfactorily at higher compression-ratios than at present on ordinary gasolines.

THE DISCUSSION

ARTHUR B. ZAENGLEIN:—I am not familiar with the method used in making the distillation tests.

GEORGE G. BROWN:—In the distillation test of the American Society for Testing Materials 100 cc. of the gasoline is placed in a distilling flask of specified dimensions which has a thermometer in its neck and a side arm through which the fuel is distilled. The flask is then heated in a shield and connected to the condenser, which is packed with ice and water, and the material is distilled into a graduated receiver. The fuel is distilled under these conditions into the receiver at room temperature at the rate of 10 cc. in 2 to 4 min. The very volatile material which comes off first is not all condensed. That we call the distillation loss. The end-point is the maximum temperature reached on the thermometer. After this maximum is reached, further heating cracks the vapors in the flask to such an extent that the temperature drops. The data obtained by reading the temperature on the thermometer corresponding to every 10 cc. distilled are plotted in temperature against percentage condensed. In this way all the loss is shown as occurring at the high end, and the curves are frequently misleading. The more rational way would be to plot the temperature against the percentage distilled rather than the percentage condensed. Then the loss is put on the front end where it belongs.

G. H. BOHN:—You will have considerable trouble unless the graduate is kept at a definite temperature. In the summer the temperature of the graduates will reach 90 deg. fahr., and in the winter it will come down to 60 or 70 deg. fahr.

PROFESSOR BROWN:—With the conventional method of plotting, the variations in the distillation loss due to changing temperature and pressure affect the whole curve, because the starting point is the initial point at which the losses occur. But, with the suggested change in plotting, making the end-point the starting point, these errors are virtually eliminated, because changes in room temperature do not appreciably affect the end-point. Because of the effect of room temperature upon distillation loss, I believe distillation loss is a very unsatisfactory specification. With the suggested modification in plotting distillation data, even though different distillation losses occur, you will have exactly the same distillation curves, at least above the 8 to 10-per cent points. This is entirely satisfactory, because ease of engine starting is best indicated by the 10 to 20-per cent range of the distillation curve.

A MEMBER:—Is not 15 or 20 per cent a little low in considering starting? We have found that it is more nearly 30 per cent. If the automotive industry would reduce the heat that is put into the manifold and carbureter, it would get a more volatile fuel.

PROFESSOR BROWN:—If 10 per cent of the fuel is vaporized in starting, no trouble should be experienced in obtaining the first explosion. If warming up is included as a phase of starting, I should go even higher than 30 per cent, preferably to 40 to 60 per cent. If 10 per cent is vaporized when using the choke, it will deliver about a 10-to-1 or 15-to-1 air-fuel ratio in the gaseous phase, whereas only a 20-to-1 air-fuel ratio is required to maintain an explosive mixture.

I think there is real truth in your last statement, as the oil industry is now able and willing to supply fuels of high effective volatility but is limited by the heating of the carbureters.

WILLIAM EDGAR JOHN[3]:—What is the basis of expressing antiknock value?

PROFESSOR BROWN:—The industry uses benzol value generally, with fairly satisfactory results. The benzol value is usually determined by comparing the knocking tendency of a test sample with various blends of benzol with a "standard" badly knocking fuel. The test fuel has a benzol value equal to the percentage by volume of benzol in a blend with the standard fuel which produces the same knocking tendency as the test fuel. Unfortunately, all laboratories do not assent to this definition, so there is more confusion regarding benzol values than is necessary.

HOW THE KNOCKING TENDENCY IS TESTED

MR. JOHN:—How is the knocking tendency tested, by ear?

PROFESSOR BROWN:—All of our tests are based both on audibility of incipient detonation and on power readings, with more weight given to the latter. Other laboratories may use similar methods or widely different methods. Practically the same results are obtained on a multi-cylinder engine as on a single-cylinder engine if a comparatively dry mixture is used.

MR. JOHN:—Does changing the spark-advance change the top compression-ratio?

PROFESSOR BROWN:—Higher compression-ratios demand less spark-advance for maximum power on all fuels, whether they knock or not.

MR. JOHN:—Does a higher compression-ratio increase the exhaust temperatures?

PROFESSOR BROWN:—I think actual tests show lower exhaust temperatures at higher compression-ratios. Probably any increase in temperature is due to some knocking, which causes overheating of everything.

MR. JOHN:—At what water temperature do you usually run?

PROFESSOR BROWN:—At 175 deg. fahr. out of the engine-block at the exhaust valve in the variable-compression engine, and at 160 deg. fahr. out of the head on the fixed-compression engine.

NEED NOT DESIGN MANIFOLD FOR TURBULENCE

CHAIRMAN W. R. GORDON[4]:—With the hot manifold, is turbulence so necessary as it was?

PROFESSOR BROWN:—I do not believe it is necessary

[3] A.S.A.E.—Engineering sales, Buffalo Gasoline Motor Co., Buffalo.

[4] M.S.A.E.—Sales engineer, Pierce-Arrow Motor Car Co., Buffalo.

to design a manifold particularly for turbulence, although I know some improvement can be made in this way.

QUESTION:—Have you done any work on volatility at different pressures?

PROFESSOR BROWN:—We are doing a little work along that line now. However, I do not think it is so important as getting volatility at different temperatures, because, as soon as the throttle is opened for acceleration, the manifold pressure is practically atmospheric.

L. F. HOYT:—What portion of the curve indicates the antiknock points?

PROFESSOR BROWN:—We have found the 50-per cent point satisfactory, provided only those fuels produced from the same crude without cracking are being compared. A California gasoline cannot be compared on this basis with a Pennsylvania gasoline.

MR. ZAENGLEIN:—Do engines with superchargers act much differently?

PROFESSOR BROWN:—Supercharging would increase the knocking tendency.

A MEMBER:—I had a car in which the valve seized when using a highly volatile gasoline.

PROFESSOR BROWN:—A carbureter cannot be expected to function efficiently with both a high and a low-volatility gasoline. The best aviation fuel I have found is an extremely volatile fuel of relatively low vapor-pressure condensed from natural gas, and it tends to run the engine cooler.

CARBURETERS SHOULD BE KEPT COLD

GUSTAF CARVELLI[5]:—With a high end-point gasoline, does not a heated manifold prevent some of the fuel from going down into the crankcase?

PROFESSOR BROWN:—I think the manifold will be heated so long as we have high end-points. The trouble is caused more by heat in the carbureter than in the manifold. The carbureter should be cold, but the temperature of the mixture in the manifold may be 150 deg. fahr., corresponding to a manifold-wall temperature of 200 to 250 deg. fahr., without loss in power or in fuel economy with present ordinary gasoline.

So far as crankcase-oil dilution is concerned, the cause of serious dilution is not a wet mixture of proper proportions, but excessive use of the choke, particularly with cold cylinder-walls.

A MEMBER:—You specified different evaporation temperatures for different atmospheric temperatures; in other words, different specifications should be used for summer and winter fuels.

PROFESSOR BROWN:—Yes, we have suggested specifications for four different fuels for atmospheric temperatures of 90, 60, 30, and 0 deg. fahr. Fuels meeting these specifications will give substantially the same performance at the four temperatures. One large refining company is now getting weather reports and blending its fuels to meet the temperature conditions expected when the fuel will be delivered to the ultimate consumer.

A MEMBER:—Does one of your blends cost any more to produce than another?

PROFESSOR BROWN:—No, there are companies that know they can market fuels at the standard price which will perform just as well as their premium fuels in all ordinary engines; but, if they did this, they would not be able to sell any premium fuel at the higher price.

EFFECT OF FLAME PROPAGATION ON DETONATION

EDWARD T. LARKIN[6]:—What influence on detonation has the rate of flame propagation?

PROFESSOR BROWN:—That involves some discussion of what is a knock. I think it has been definitely proved that a knock in an engine is caused by a complex reaction of some kind occurring ahead of the flame initiated by the spark. The more rapid the rate of flame travel, the more rapidly will the unburned gas be compressed and the more intense will be this reaction. If we assume that the complex reaction is due to some form of auto-ignition, a high rate of flame travel will tend to increase detonation and a high ignition-temperature will tend to prevent detonation. In general, these conclusions are borne out. Benzol burns very fast but has a high ignition-temperature. Alcohol has a much lower ignition-temperature, but also a much lower rate of rise of pressure which more than compensates for the low ignition-temperature.

A MEMBER:—What effect on the knock has the carbon on the top of the piston?

PROFESSOR BROWN:—First, carbon takes up space and increases the compression ratio. Secondly, the carbon becomes hot and aids in auto-igniting the unburned fuel that is being compressed. If the inside of the combustion chamber could be kept cool, it would greatly improve conditions so far as knocking is concerned.

MR. LARKIN:—In some experiments that we conducted with an L-head engine having a combustion chamber similar to Ricardo's, the engine proved to be one of the worst knockers I ever heard. By controlling the flow of fuel in the cylinder during the suction and compression strokes, we were enabled to use higher compression, whereas the action of some so-called turbulence failed.

CONTROL OF TURBULENCE SHOULD HELP

PROFESSOR BROWN:—I think a good deal can be done along the line of control of the turbulence. I do not believe we shall see engines much above a 6-to-1 compression ratio in general use for some time, because of mechanical limitations.

MR. LARKIN:—Theoretically, it should be possible to go to 9-to-1-compression ratio with alcohol as a fuel, but the heated parts and the residual gas in the combustion chamber transfer heat to the charge, which prevents use of this high compression except on very slow-turning engines. We have found in tests which we ran with high compression-ratios that the points of the spark-plugs were oxidized and would absolutely disappear. I have seen ratios of approximately 6 to 1 employed with the use of tetraethyl lead with the result that the porcelain glass was heated to such a temperature that it fused with some of the lead and blistered so that hot-spots were formed which were much more active. That was before the Bureau of Mines controlled that fuel to the extent of limiting the amount of "dope" to be used. Engines of high compression can be run only by those who understand what is happening inside the engine. Very few of us know what happens in an engine, but the public is using devices today that it could not have used years ago, and will ultimately be able to use other mechanical constructions that it does not seem capable of using today.

[5] M.S.A.E.—Chief draftsman, Curtiss Aeroplane & Motor Co., Buffalo.

[6] M.S.A.E.—Chief engineer, Sterling Engine Co., Buffalo.

The Automatic Fabrication of Automobile Frames

By JOHN P. KELLEY[1]

DETROIT SECTION MEETING *Illustrated with* PHOTOGRAPHS

NEARLY all steel used in this process of manufacturing frames comes to the plant in the form of strips, which are rolled to remove curvature and inspected automatically for dimensions. All operations and handling are automatic, except pickling, cleaning and oiling the stock and inspecting the assembled frame, until the enameled frame is ready to be shipped.

Economical use of the strip steel is dependent upon an offsetting operation that makes the strip conform to the vertical curves desired in the finished frame.

With the aid of illustrations, the author follows the fabricating process through the various lines and other units, until a frame is ready for shipment or storage, within less than 2 hr. after it enters the manufacturing line as strip steel.

AUTOMOBILE engineers have contributed to many romantic and at the same time practical accomplishments to this new era of industry, and our automatic frame-plant has been described as one of the most romantic and practical of these. I can recall vividly the creation of the first pressed-steel automobile frame of American make by the A. O. Smith organization for the Peerless car, I believe it was in 1903. This was followed by a step-up in daily production to 10, 25 and 50 frames, divided among the Pope-Toledo, Cadillac, Elmore, Locomobile and some of the other early automobile builders; then to 200 or more daily because of the initial production of 10,000 frames and rear-axle housings for an early Ford model.

It is hard to visualize the comparison between such early production and that of this automatic plant, with a daily capacity of more than 7000 frames, or even with that of our semi-automatic plant, with a daily capacity of approximately 4000 frames. The intervening years have brought experience, combined with some sound engineering and research. Among the developments have been our present standard specifications for frame material, new features of tooling and new methods of production. Outstanding among the production features are:

(1) The cold-riveting of frames in assembly, including the development of cold rivets of the proper quality for this purpose

(2) Flexible and semi-flexible blanking and piercing

[1] Sales manager, A. O. Smith Corporation, Milwaukee.

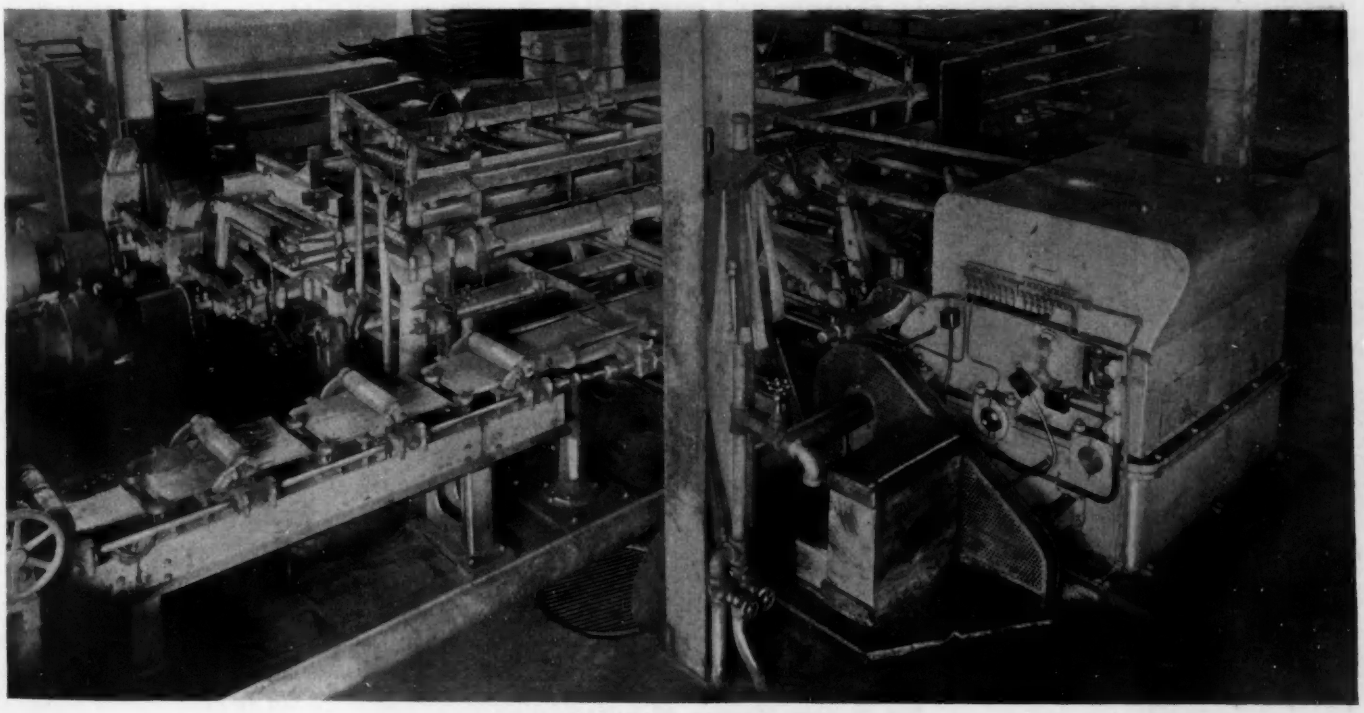


FIG. 1—AUTOMATIC INSPECTION MACHINE FOR STRIP STEEL

This Machine Rolls Out Any Curvature in the Strips, Inspects Them for Three Dimensions and Curvature, and Places Passed and Rejected Strips in Separate Piles

dies, which effect a considerable saving compared with the cost of solid dies and are a big time saver, especially on initial runs involving new tooling

(3) The vertical offsetting of side-member blanks for the kick-up over the rear axle and for front and rear-end drops, which effects a reduction in blank sizes and makes possible the economical use of high-carbon strip steel
(4) Forming the end laps or riveting ears of cross-members automatically during the drawing or channeling operation
(5) Continuous line and group operation, extending from the pressing operations to and including the final assembly and inspection
(6) Automatic painting and loading of the frames

The erection of this automatic plant was started in 1919 and completed in 1920, but very intensive engineering work in the development of both the equipment and the plant occupied the five years previous, except for interruptions during the war period. The enterprise presented an engineering problem of gigantic proportions, because there was no automatic installation in existence to furnish a guide and the various production units had to be created and synchronized. The 552 operations required on the normal frame at a speed of 360 frames an hour aggregate approximately 4,000,000 operations in a day's production of 7000 frames. This automatic plant is 600 ft. long and 212 ft. wide, with a floor area of 129,600 sq. ft.

Inspection of Stock Is Automatic

All the steel used for side-members and most of that used for cross-members is rolled in strips. Every strip, as it comes to the factory, passes through the combination straightening and automatic inspection machine, known as unit No. 1, part of which is shown in Fig. 1. The strips first pass between rollers at the left, which remove any curvature, and then come to the gaging fingers and rollers shown at the right. Each strip that comes within the established limits of length, width, thickness and curvature is automatically stacked in a pile of passed strips, and any strip coming outside the limits actuates an electrical mechanism that energizes magnets to lift the rejected strip and place it on a separate pile. This machine has a capacity of 900 strips per hr.

From the inspection machine, steel is carried by a monorail conveyor to the pickling department, which is unit No. 2. No automatic scheme for pickling has been accepted as economical, because of the high maintenance cost on conveyors and carriers. The equipment used consists of crates, made from acid-resisting metal, with provision for separating the strips. Each crate has a capacity of about 5 tons. The same crates pass through the acid, rinsing, alkali and oil tanks, the last to give a protecting coat of oil that is sufficient for the fabricating operations. This department has a capacity of 500 to 600 tons in a 20-hr. day, with a crew of seven men in each shift.

Transportation from the pickling unit to the feeder of unit No. 3, the side-member manufacturing line, is also by monorail crane. From this point the strips pass automatically over the line, actuated by a reciprocating conveyor. All six presses in this line are driven by a single 500-hp. motor, to assure perfect timing of the various operations. In addition, each press has an individual motor for slow-speed operation in setting up and for finishing samples for production inspection.

Protection against damage to the machinery from overloading is given through instruments located in

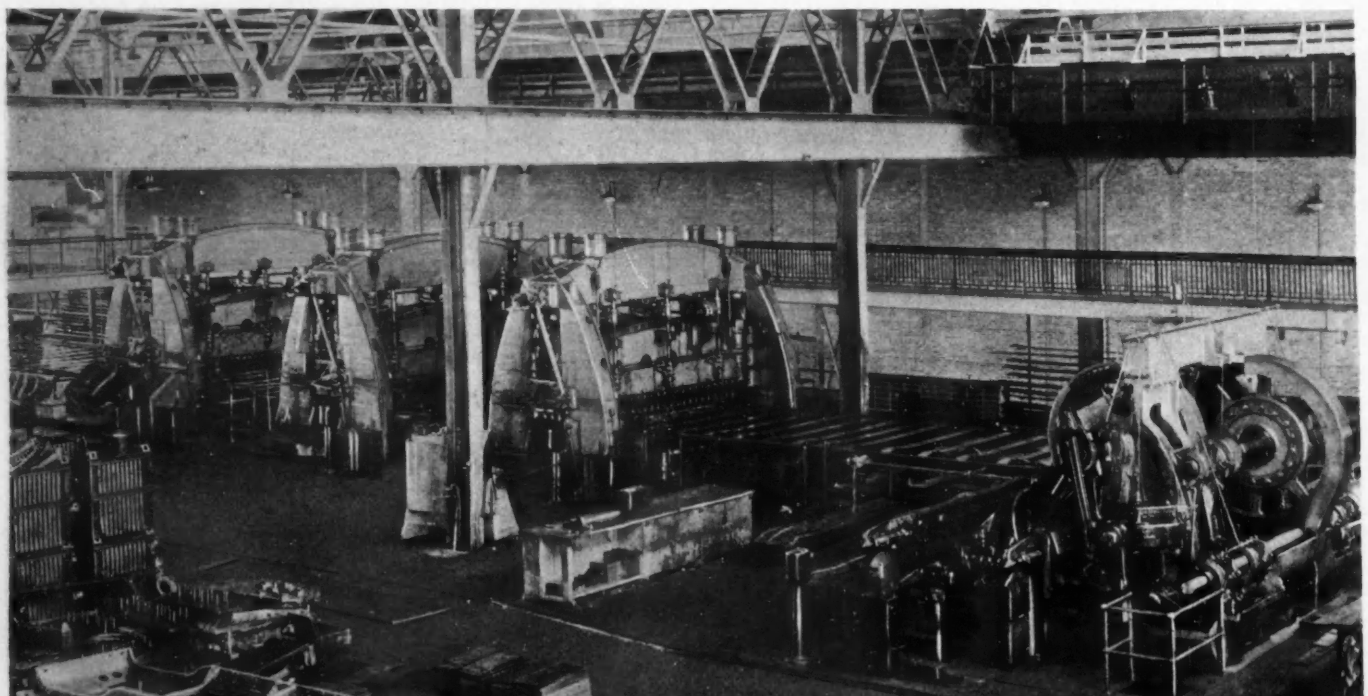


Fig. 2—Side-Member Manufacturing Unit

The Press at the Right Offsets the Strip to Conform to the Vertical Curvature of the Frame, the Next Two Presses Pierce Left and Right-Hand Members, and the Fourth Press Blanks All Members. Feeding and Transfer Are Automatic. The End of This Unit is Seen in Fig. 3

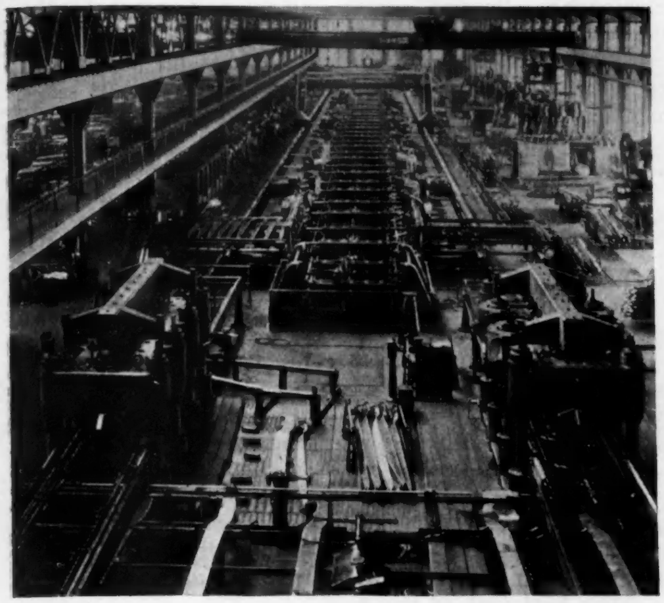


FIG. 3—SIDE-MEMBER ASSEMBLY UNIT

Each Carriage in This Line Carries a Pair of Side-Members Through 19 Stations Where Brackets Are Added. In the Foreground Is the End of the Side-Member Manufacturing Unit, with the Forming Presses Just Beyond

plain sight of the operators. The line can be stopped from any working station; but it can be started from one station only, and only when all operators have signaled for the start.

STRIP STOCK UPSET FOR CURVES IN FRAME

The first operation in unit No. 3 is offsetting the blanks for the kick-up over the rear axle and for the curves at the ends. This is done in the press shown at the right in Fig. 2. On the feeders for the offsetting presses are two magnetic carriers, each with from 6 to 10 electromagnets, according to the length and weight of the bar. The two carriers are attached to a cable so that as one takes the straight blank into the press the other is removing the offset blank. Right and left-hand blanks are offset alike.

From the offsetting press the strips are carried along the line to the piercing presses. The first of these pierces the left-hand bar and the second pierces the right-hand bar, each bar passing through one press without working. Locating notches are made in each member during the piercing operation to secure accurate registering in the blanking press, which comes next in line. This is the press farthest to the left in Fig. 2. The blanking press works on each bar, as the blanks are of the same form. Scrap from the blanking press falls to a lower floor level and is chopped up.

In the foreground of Fig. 3 is shown the end of the side-member manufacturing line, beyond the blanking press. The side-members move from left to right in this view; and every other one is taken from the line and transferred to the press at the left, which forms the left-hand members, by fingers that are almost human in their action. The right-hand members pass by this press and are turned over by the fingers in the center foreground of the view before they reach the end of the line, where they are transferred to the forming press at the right. The capacity of this line is 450 pairs of side-members per hour.

From the forming presses the side-members go to the beginning of the side-member assembling line, seen beyond the presses in Fig. 3. This is designated as unit No. 5, and is driven by one 200-hp. motor. There are 38 trucks on which the members are loaded automatically in pairs, as shown immediately beyond the presses. A reciprocating conveyor moves the trucks down the line, approximately 400 ft. long, with stops at each of 19 stations. They are then lowered by an elevator, and returned by a screw conveyor to the beginning of the line where they are elevated again.

At each of the 19 stations several machines are at work, pinning and riveting brackets in place to complete the side-member sub-assemblies. The total number of operations is 68. The line has a capacity of 450 pairs of side-members per hour.

FOUR LINES REQUIRED FOR CROSS-MEMBERS

Side-members are handled in pairs as there are two to each frame, but cross-members are handled individually; so four manufacturing lines, each with a capacity of 450 members per hr., are required to keep step with the production capacity of 450 pairs of side-members per hour.

Each of these four lines includes a blanking press, which also pierces holes that are not liable to distortion in drawing; a drawing press, which forms the end laps as well as the channel or other section required; automatic drilling machines, to make holes not provided for in the blanking press; and small power-riveting presses, for the completion of cross-member sub-assemblies, if required. A 100-hp. motor is used for each line. Steel is fed to the four lines by automatic feeders and car-

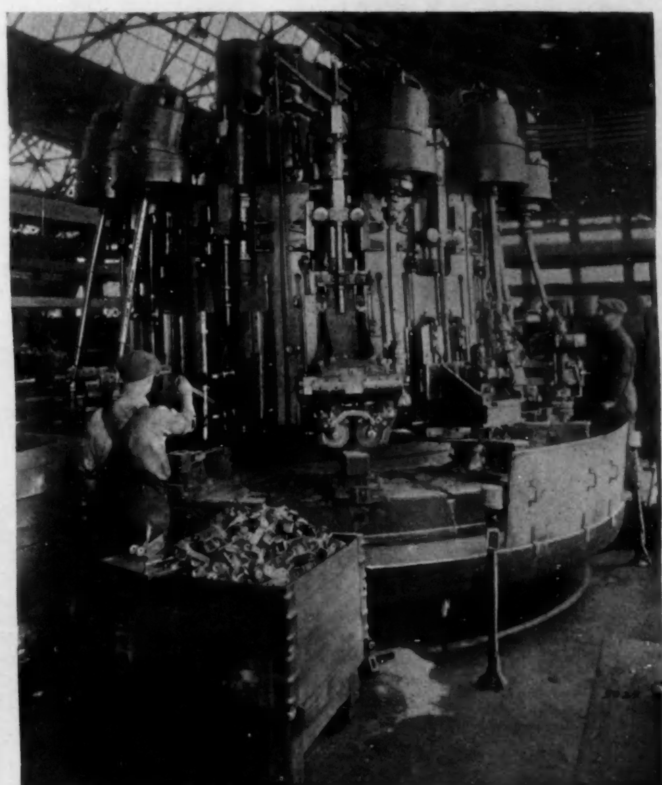


FIG. 4—SPRING-HANGER FINISHING MACHINE

This Special Automatic Machine Has 12 Stations and Does All Finishing Operations at One Chucking. Four Such Machines Are Used

ried between the presses on reciprocating feeders. The operations are very much like those in the side-member manufacturing line. Finished cross-members are carried by conveyors directly to the general assembly line. Three of these cross-member manufacturing lines can be seen in the background of Fig. 5.

For machining the castings required for the various spring hangers and brackets on frames there is a machine department in the automatic building having a capacity of about 100,000 castings per day. It is equipped with a variety of standard machine-tools and several special machines. This department finishes castings for the semi-automatic as well as the automatic frame-making plant of the corporation.

There are four special machines, like that shown in Fig. 4, for finishing spring hangers at a rate of 450 per hr. each. The machine has 1 loading station and 11 working stations, and all machine operations are performed with only one chucking of the part. These machines can be seen also at the right in Fig. 3.

Automatic Final Assembly, Too

Final assembly of the side-member and cross-member sub-assemblies is done in unit No. 6, which is shown in the foreground of Fig. 5. Conveyors bring the sub-assemblies to the final assembly line, where they are picked up automatically, clamped together in correct relationship, "nailed" with rivets and permanently joined by heading the rivets.

The line under the bridge on which a man is standing, in Fig. 5, is the first of the four lines. While side-members are stopping at the several stations of these lines, the various cross-members are put in place and the rivets nailed in place. Each frame is mounted on a long narrow car with four flanged wheels and adjustable fingers to support the side-members, and the cars are moved from station to station by reciprocating pushers. At the end of the first line, containing seven stations, the car and frame together are transferred across to the second line.

Rivets are fed into tubes from hoppers at the lower level, below the assembly lines, and are carried to the riveting guns by compressed air. Approximately 90 rivets are nailed in place in each period of about 10 sec.

Heading the rivets is done in the two lines in the foreground of Fig. 5. The riveting heads are of four types, with various shaped jaws, made adjustable so they will reach any point desired. Each works on one rivet and is mounted on a sliding platform so that it can move back out of the way.

In the riveting there are three separate actions, accurately timed: (*a*) The forward action of the feeder and trucks carrying the frames, (*b*) movement of the

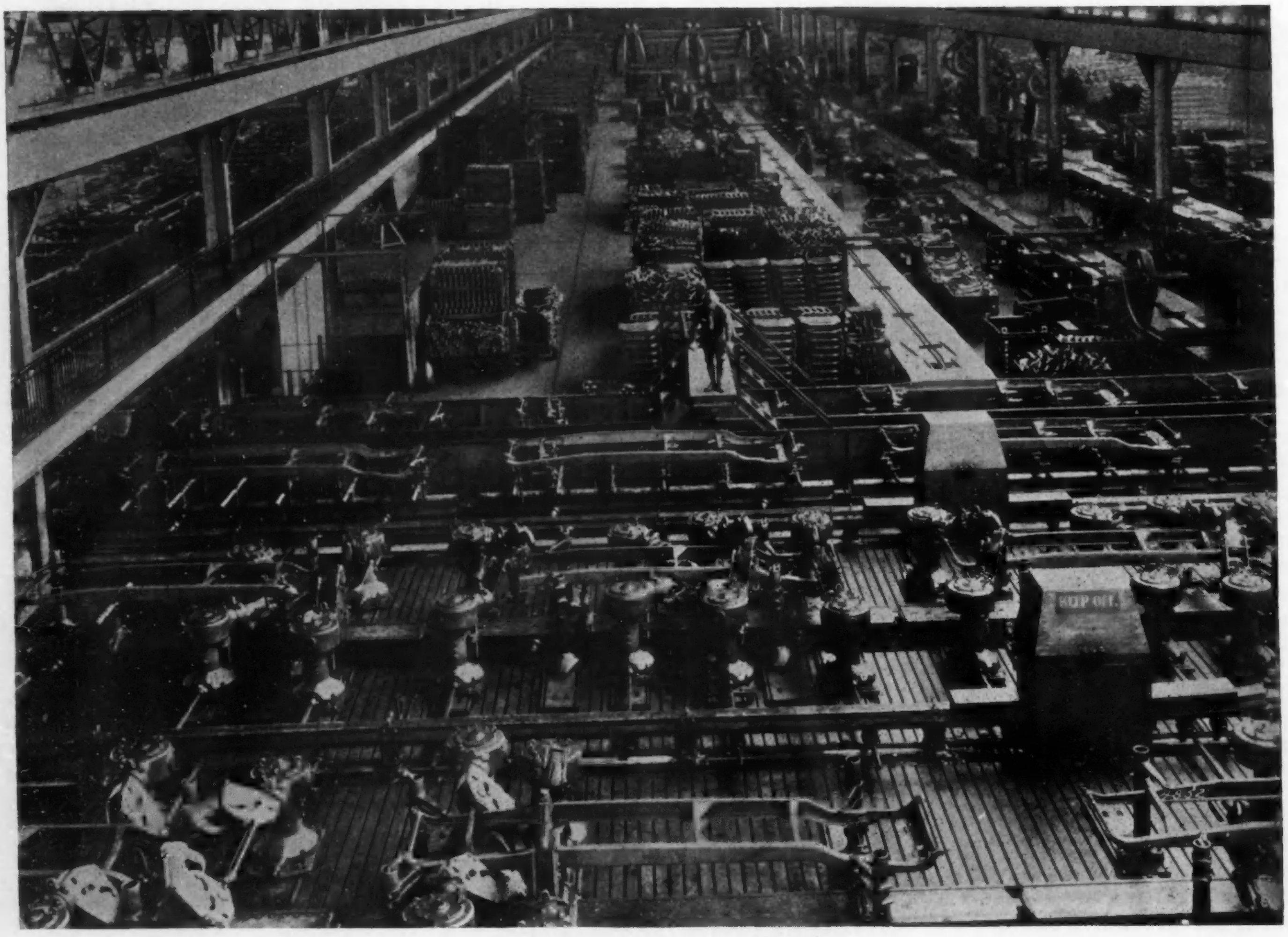


Fig. 5—General Assembly Unit

In These Four Lines the Prepared Sub-Assemblies Are Clamped, Pinned and Riveted Together into a Complete Frame. In the Background Are the Cross-Member Fabricating Units, with Three Presses of Fig. 2 in the Extreme Background

riveters into position, and (*c*) the action of the riveter jaws. The riveting pressure required is more than 20 tons. To reduce the peak load on the machine, the heading is done in two steps. The 250-hp. motor that drives this unit, together with much of the actuating mechanism, is located on the lower level. The capacity of this unit is 360 frames per hour.

This assembly line has operated continuously, day and night, for 7 days without stopping except for 6 min. each morning and night. During this time it was necessary to change 12 rivet sets, but the replacements were made without stopping the machine.

Inspection Is Not Automatic

Up to this point the frame has had no hand work or handling, but after it is assembled it is checked with gages by inspectors, while passing through unit No. 7 on conveyors, to see that the various holes and locating points are in alignment and correct. But the parts must be correct to be assembled automatically, and if the parts are right there is little chance for error in the final assembly. In addition to the routine inspection there are several inspections each day by men from the research department, which is working constantly for a finer development of frame manufacturing.

After passing through the inspection line the frames go to the automatic washing and enameling unit, designated as No. 8. They are cleaned free from the oil and dirt that have accumulated in manufacturing, in a machine to which they are fed automatically. After drying in this machine they are discharged by gravity to the loading station of the painting machine. In this machine high-temperature baking-enamel flows at the rate of 750 gal. per min. The excess is drained off and returned to the tanks. In the painting unit is a conveyor chain about 700 ft. long, which carries the frames through a two-story oven. The time of baking is 1 hr.

After the steel is pickled it requires only 40 min. to fabricate a complete frame. Including the inspection, enameling and baking time, it is 1 hr. and 50 min. from the beginning to the end of the frame manufacture, and 90 per cent of that time is spent on conveyors.

Rivet sets in the assembly line can be changed without stopping the line. This change can often be made within 30 sec., but the average time is between 1 and 2 min. When a complete change-over is made from one type of frame to another, a gang of 200 station men does the job in 10 hr. This time will be reduced to 8 hr., it is expected.

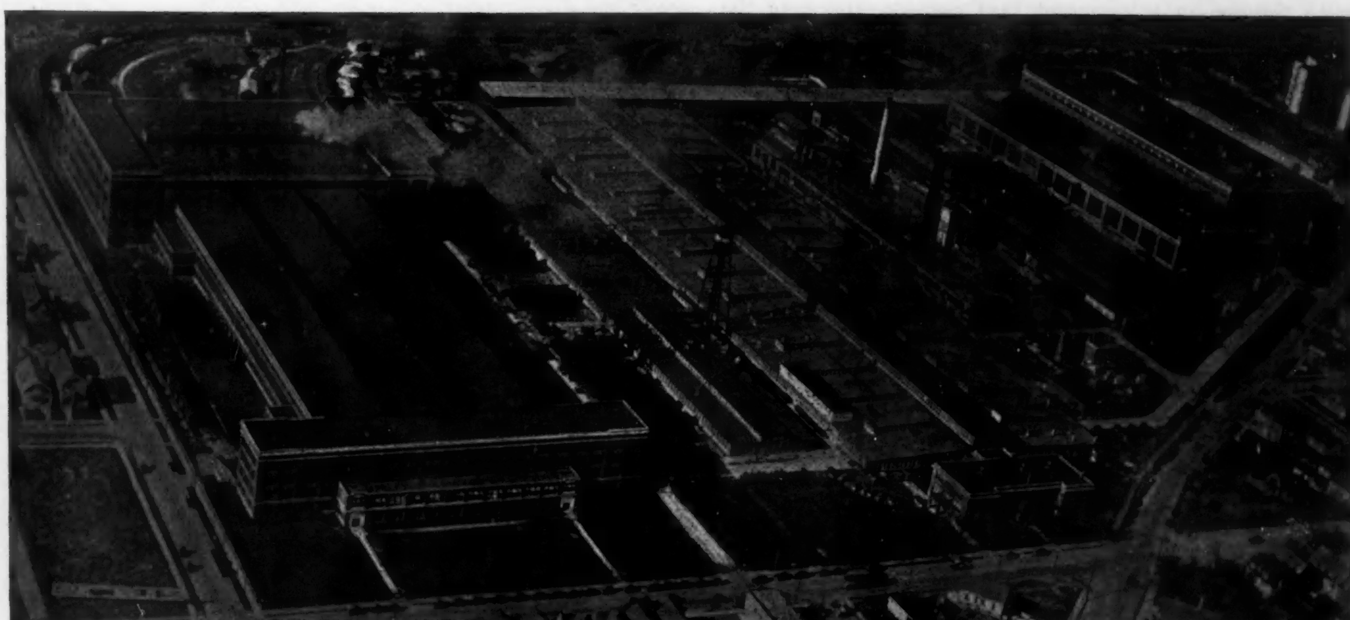
Large Storage Facilities Required

There remains one more link in the chain, unit No. 9, for storage. As shipping schedules cannot be made to conform to the production rate of this plant, it is necessary to provide a large storage reservoir. This is located in a storage house 335 ft. long and 216 ft. wide, attached to the rear of the automatic plant. This building, which is 74½ ft. high, is divided horizontally. The lower 40 ft. has a capacity of about 52,000 tons of steel and the upper 38 ft. provides room for 50,000 completed frames, stored in racks at four levels. Outside the building is a supplementary storage yard with room for 82,000 frames. This yard is served with swinging cranes operating from the ground. Separate monorail crane systems are provided in the storage building at the 40-ft. and 78-ft. levels.

Shipping docks are provided both inside and outside the building, with a total loading capacity of 12,000 frames in a 9-hr. day.

Passenger-car frames that are required in lots of over 10,000 and in quantities of not less than 75,000 yearly are manufactured in this automatic plant. All other frames are made in the semi-automatic plant.

An outsider who gets a casual view of this plant in operation is attracted by the spectacular performance of the automatic machinery on the lines; but we, as an organization, are interested primarily in the fact that the plant is a commercial success, both as an investment and in the character of its product.



Automotive Phases of Carbon Monoxide Research Summarized

In assuming its increasingly large rôle in modern transportation, the automobile has been called upon to guard against infringing on the rights and the comfort of its neighbors. The carbon-monoxide content of exhaust gases, for instance, has been a subject of diligent and careful study, which has been pursued with greater intensity with the growth of traffic congestion and the increased use of vehicular tunnels. In view of this interest and of the desire for information on certain specific points indicated by inquiries made to the Research Department, the Research Committee directed that an article be prepared for this section of THE JOURNAL briefly summarizing the main points of the general research, and dealing in somewhat greater detail with the following subjects of special interest to the automotive industry: the carbon-monoxide content of air in garages, streets and tunnels due to automobile exhaust-gases; the physiological effects of such concentrations of carbon monoxide on human beings; and the use of ozone in combating the carbon-monoxide health hazard in garages.

Complying with the instructions of the Research Committee, recourse was had to both the literature and the following organizations known to have carried out or to be carrying out research on the topics involved: Bureau of Mines Experiment Station, Pittsburgh; United States Public Health Service; the Bureau of Industrial Hygiene, New York State Department of Labor; and the Carbon Monoxide Committee formed under the auspices of the American Chemical Society. The material secured and the articles comprising the bibliography are grouped under six headings, covering the topics on which information was sought. The numbers in the text indicate the sources of the information, and correspond with items in the bibliography. The six headings listed in the order in which the topics are dealt with are: (*a*) General Research on Carbon Monoxide, (*b*) The Carbon-Monoxide Content of Air in Garages, Streets and Tunnels, Due to the Exhaust-Gases from Automobiles, (*c*) The Physiological Effect of Carbon Monoxide, (*d*) The Chemical Aspects of the Use of Ozone in Meeting Carbon-Monoxide Health-Hazards, (*e*) The Physiological Effects of Ozone in Ventilation, and (*f*) Studies of the Use of Ozone in Garage Ventilation.

RESEARCH on a phenomenon that man introduced with the discovery of fire and that manifests itself in at least 24 known departments of modern industrial life (219) naturally has been too extensive to permit the making of a detailed account in a summary article of this nature. The task has been performed ably by the United States Public Health Service in a pamphlet that surveys and lists the published material covering carbon-monoxide studies (22). The following extremely sketchy outline will indicate the scope and the intensity of study and experiment on the source, action, and preventives of and remedies for the effects of the poisonous gas.

Carbon-monoxide poisoning is far from being an exclusive concomitant of modern industrialism. Ancient literature (66, 69, 188) describes a number of what can be recognized as carbon-monoxide cases, indicating that this gas was a frequent cause of death through accident, suicide, or use as an instrument of punishment or torture. However, at the time, neither the nature nor the source of the evil was clearly understood; even as late as the eighteenth century death from carbon-monoxide poisoning was sometimes superstitiously attributed to the devil (70). Toward the close of that century a decisive advance was made into the as yet unexplored realm by several investigators who made carbon monoxide experimentally (1776) (7). Gaining momentum from its early start, the carbon-monoxide health hazard has increased with each development of a more efficient method of producing heat, until it is said to be today one of the most widely distributed and frequent causes of industrial accidents (205).

Even the earliest observers of carbon-monoxide poisoning noted its symptoms, and now, with the aid of late investigations, a formidable list of indications of the excessive presence of the gas has been drawn up. Some of its items are: headache, weariness, weakness, dizziness, nausea, vomiting, loss of strength and muscular control, increased pulse and respiratory rates, loss of reflexes, coma with intermittent convulsions, cessation of respiration, and death (219).

Neither the early start nor the rapidity of progress that mark the discernment of carbon-monoxide poisoning symptoms characterizes the study of its pathology. Investigators are not yet in absolute accord as to the reaction in the body to carbon monoxide. The first real approach to a true conception of what takes place in the presence of the gas was made with the discovery of the change in the color of the blood on contact with the gas. This led to the further realization that the poisonous action of carbon monoxide is due solely to its power of combining with the red coloring matter of the blood (139, 167, 201, 208).

DETECTING AND OBVIATING CO HAZARDS

Apparatus to detect and determine the quantity of carbon monoxide in the blood and air has been the objective of much research. A number of methods for the determination of carbon monoxide in the blood have been developed, such as the spectrophotometric (238), the colorimetric (152), the gasometric (181), the ferricyanide (145), the measurement of the respiratory capacity of the blood (171), the use of a formaldehyde solution (210) and a modification of the spectrophotometric method (177). All of these are said to be open to some objections, and two more satisfactory procedures have been developed recently, the pyro-tannic acid method for the determination of carbon monoxide in both blood and air (222), and the iodine-pentoxide method for its detection in air (8).

A satisfactory treatment for carbon-monoxide poisoning

waited upon the discovery that the combination of carbon monoxide with the hemoglobin of the blood is not permanent, and that the poisonous gas can be replaced by oxygen just as it initially supplants the oxygen. The administration of oxygen as a restorative has proved very effectual (194, 226, 227). The addition of carbon dioxide (174, 190, 191, 216, 199), hastens the elimination of carbon monoxide from the blood but, due to the danger of failure of the heart (221), already weakened by severe poisoning, its general use is not unqualifiedly recommended.

Preventives for carbon-monoxide poisoning have been sought even more assiduously than cures. Adequate ventilating systems (219) and protective equipment (19) for use in gas-tainted atmosphere have been developed; and much earnest effort has been made to reduce the hazards to the minimum by the proper construction and adjustment of appliances responsible for the generation of carbon monoxide (15, 18).

Carbon Monoxide Due to Automobile Exhaust-Gases

In this general scene of carbon-monoxide menace, the part assignable to the automobile can be properly oriented. The root of the whole question is, How much carbon monoxide is contained in the exhaust gases of automobiles, and to what extent does this contaminate the air in streets, garages and vehicular tunnels?

Fortunately, reliable and comprehensive information is available on the basic issue. It was obtained by the Bureau of Mines in an investigation made for the New York and New Jersey State Bridge and Tunnel Commissions (47). To determine the average amount and composition of the exhaust gases from motor-vehicles under operating conditions that prevail in the Holland Tunnels, the Pittsburgh Experiment Station conducted a full set of road tests on 101 motor-vehicles, including representative types of passenger-car and of truck. The tests were made over the period from Dec. 1, 1919, to Sept. 30, 1920, thus including both winter and summer conditions. The cars were selected at random from vehicles in current use and no carbureter or other adjustment was made; therefore the results may be accepted as representative of general operation. The data developed are given, in the report cited, in clear and extensive detail; they are summarized in three charts here reproduced as Figs. 1, 2 and 3.

With these basic data, the probable carbon-monoxide content of the atmosphere of any enclosed space can be calculated by the following formula (50):

$$C = 100\ K/RV\ (1 - e^{-Rt})$$

where C is the percentage of carbon monoxide in the space under investigation for a given time; R, the ventilation, or air changes per unit time; t, the time; V, the volume of the space in cubic feet; and K, the cubic feet of carbon monoxide liberated by the engine or engines per unit time.

Observations in Public Garages

Of actual observations of the carbon-monoxide content of air in public garages, three may be cited. (Concentrations of carbon monoxide are generally expressed in parts of carbon monoxide per 10,000 parts of air, and references here made will follow this practice unless otherwise specified). The Bureau of Industrial Hygiene of the New York State Department of Labor, beginning in November, 1923, made a series of such studies in 31 garages and found in one garage a gas content of 20 parts; in 9, 15 parts; and in 7, 5 parts (49).

The author of this report points out that the average carbon-monoxide content of the air in the garage is not a true indication of the health hazard for garage workers. He cites an instance in which an air sample taken in a garage 10 ft. from the exhaust of a running engine and 4 ft. from the floor showed 10 parts of carbon monoxide, while 30 ft. from the car a positive test for carbon monoxide could not be obtained.

Later observers, S. H. Katz and H. W. Frevert (56), characterize the findings of this investigation as hardly representative of conditions in large garages; although "grab" samples taken in adverse situations in small garages, they say, would have such comparatively large concentrations. Katz and Frevert made continuous records of carbon monoxide through nearly three weeks of January, 1927, in the Government Fuel-Yard Garage, City of Washington, and through most of February to May, 1927, in a large public-corporation garage at Pittsburgh.

The findings may be summarized as follows:

	Maximum CO Recorded	Highest Average for Working Day	Highest Average for Hour
Government Fuel-Yard Garage	8.9 or above	Less than 1	2.80
Commercial Garage, Pittsburgh	Above 8.3	1.64	4.33

The excessively high concentrations noted existed only momentarily, and were recorded on only 5 days among the 105 covered by the investigation. Only once was 4 parts exceeded as an average for one hour. Concentrations were not found in excess of 7.0 parts under or near trucks with idling engines, excluding immediate discharge from the mufflers.

The authors caution against a too general acceptance and application of these results, since the tests were conducted in comparatively moderate weather, when ventilation is apt to be more thorough, and in large garages where considerable volumes of carbon monoxide are required for the accumulation of dangerous concentrations.

Finally, the United States Public Health Service recently made 102 tests in 27 garages in 14 cities. The average carbon-monoxide content was found to be 2.1 parts. More than half of the samples (59 per cent) contained over 1 part of carbon monoxide, and 18 per cent of all the samples contained over 4 parts of this gas.

Conditions in Private Garages

Tests made under controlled conditions more nearly representative of private garages may also be considered. In

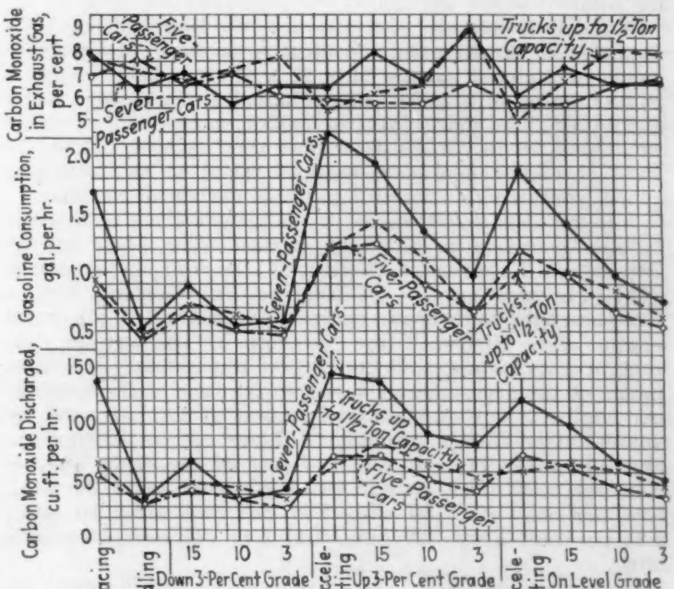


FIG. 1—CURVES SHOWING AVERAGE GASOLINE CONSUMPTION AND PER CENT AND QUANTITY OF CO IN EXHAUST GAS

The Data Were Obtained from Tests at the Bureau of Mines of Five-Passenger and Seven-Passenger Cars, and Trucks up to 1½-Ton Capacity under Winter Conditions. They Represent the Average of Light and Full-Load Tests

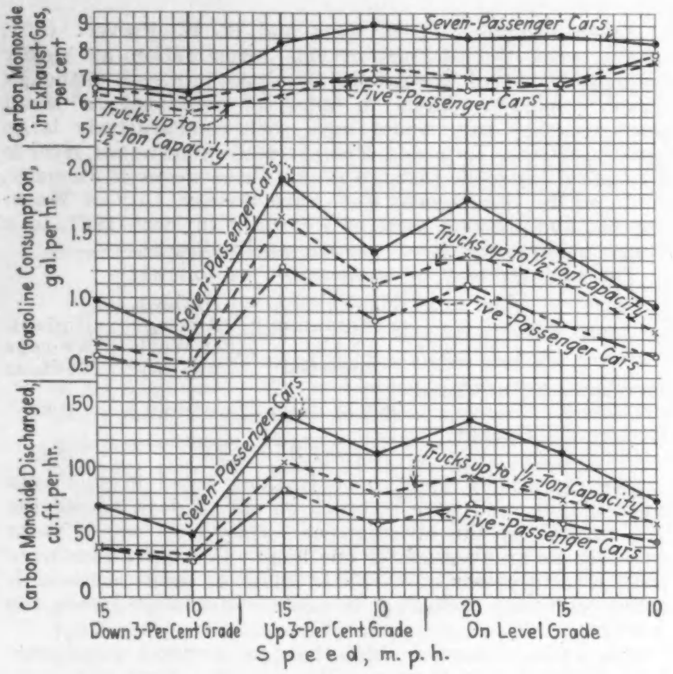


Fig. 2—Curves Showing Average Gasoline Consumption and Per Cent and Quantity of CO in Exhaust Gas

The Data Were Obtained from Tests at the Bureau of Mines of Five-Passenger and Seven-Passenger Cars, and Trucks up to 1½-Ton Capacity under Summer Conditions. They Represent the Average of Light and Full-Load Tests

1919 (43) the Bureau of Mines measured the carbon-monoxide content of the air in a closed garage of about 5000 cu. ft. capacity in which a four-cylinder, 3¾ x 5⅛ in., 30-hp. engine was run. Dangerous amounts of carbon monoxide were found in the farthermost parts of the garage after the engine had been operated 20 to 30 min., and near the machine the air was extremely unsafe after 15 min.

Yandell Henderson and Howard W. Haggard, in 1923, reported to the American Medical Association observations made in a closed garage 11 x 20 x 23 ft. (220). After 5 min. running of a truck engine, samples of air were found to contain 7 or more parts of carbon monoxide. A round ventilator 16 in. in diameter was then opened. After 10 min. of engine operation samples taken at two different places contained 7.4 and 9.2 parts of carbon monoxide.

Similar tests to determine the dangers arising from automobile operation in a closed garage were made at the Pittsburgh Experiment Station of the Bureau of Mines (50). In this garage, of 2950 cu. ft. capacity, first a five-passenger touring-car engine and then a 1½-ton truck engine were run until the lowering of the oxygen content of the garage made operation impossible. Measurements of the atmosphere showed, in the case of the touring-car engine, a carbon-monoxide content of 1.31 per cent by volume after 25 min. running, 1.97 per cent after 60 min., and 2.10 after 112 min.; in the case of the truck engine, 0.42 per cent after 10 min., 1.18 per cent after 30 min., 1.91 per cent after 60 min., 2.17 per cent after 90 min., 2.24 per cent after 120 min., and 2.43 per cent after 175 min.

In connection with the carbon-monoxide dangers in garages, G. W. Jones and S. H. Katz have presented a study on the volume of the gas that may be discharged from cars in a garage and the volume of air necessary to dilute it to 1 part, which is recommended as a safe concentration for workers in garages and shops. (48). Natural ventilation is thought sufficient to achieve this end in the summer, when windows and doors are open, while special provision for removing the gas is said to be sometimes desirable in winter.

Tunnel Ventilation Needs

The carbon-monoxide content of the atmosphere in a well-constructed and well-governed vehicular tunnel is, of course, what you make it. Regulation of the amount of traffic and its operation and of the forced ventilation system controls the gas concentrations.

Some information is available on possible conditions where no mechanical ventilation is in operation. For 4 months the Liberty Tunnels at Pittsburgh were open to traffic under these conditions (54), the induced wind velocity set up by the stream of traffic effecting the air changes. On several occasions during this period the traffic was at the rate of 900 cars per hr., but the carbon-monoxide content reached a maximum of only 2 parts; it was less than this amount almost all of the time and usually was less than 1 part. When the mechanical ventilation system was installed, a continuous carbon-monoxide recorder was incorporated with it. When the carbon-monoxide concentration approaches 4 parts, as shown by this recorder, the fan output is increased, and when the concentration becomes less the fan speeds are reduced.

The ventilating system of the Holland Tunnel, like that of the Liberty Tunnels, is designed to hold the carbon-monoxide content of the atmosphere at or below a maximum of 4 parts. Ole Singstadt, chief engineer of the tunnel, is quoted as making the following statement concerning actual conditions there (55):

> The condition of the tunnel atmosphere was constantly recorded by 14 continuous carbon-monoxide recorders. During the maximum hourly period, between 4 and 5 p.m., in the south tunnel, the carbon-monoxide content was 142.8 parts and in the north tunnel for the peak hour, which was between 5 and 6 p.m., the carbon-monoxide was 157.8 parts in 1,000,000.

Exhaust Gas in City Streets

Entirely different is the situation with regard to the carbon-monoxide hazard in city streets. Not only are the conditions uncontrollable, but many factors must be considered to make any observations significant and valuable. The locality at which the samples are taken, the height above the street level and the time during which the concentrations noted are to be found—these are all circumstances affecting the validity of the observations as criteria of carbon-monoxide menace.

Yandell Henderson and Howard W. Haggard, for the report to the American Medical Association mentioned in a previous connection (220), made two types of observation. In the first series, the distribution of the exhaust gas behind a car standing still, but with the engine running, was noted. A few feet behind a Ford car and at about the height of the head of a man, concentrations of from 4 to 6 parts of carbon-monoxide were recorded. When the car was moving at the rate of 10 m.p.h. the occupants of a vehicle following at a distance of about 30 ft. were found to be surrounded by exhaust gas diluted to a concentration of 1 or 2 parts of carbon monoxide. In the second series of observations, "snap" or "grab" instantaneous air-samples were taken just behind a motorcoach or truck, or when traffic was stopped and crowded at a cross street or when it was just starting again. While the results varied according to atmospheric conditions and the amount and movement of traffic, the figures obtained are said to show conclusively that 1 part of carbon monoxide is a quite frequent condition in streets where traffic is heavy; and 2 parts is not unusual.

Measurements made by the United States Public Health Service check fairly well with these observations. A recent report of this work reads, in part:

Fourteen of the largest cities in the Country were visited, having a combined population of over 19,000,000, and 250 samples of air were obtained for carbon monoxide analysis. These samples were analyzed by the iodine-pentoxide method, using a liquid-air cooling tube which was shown to be necessary in order to eliminate gasoline vapor, a substance which tends to vitiate the results of the analysis. The street samples were taken in such a manner as to approach the most congested conditions that may exist at a busy traffic intersection. Hence it is felt that these results indicate the maximum hazard that may exist today in the metropolitan thoroughfares from automobile exhaust-gas.

The average of 141 tests made in city streets at peak hours of traffic showed a contamination of 0.8 part of carbon monoxide per 10,000 parts of air. Only 24 per cent of all the street samples had more than 1 part of carbon monoxide in 10,000 of air, and in only one location, a covered passageway, were there as much as 2 parts per 10,000. Samples taken inside of auto buses yielded even lower concentrations of carbon-monoxide gas. The figures for street air, when viewed in the light of present-day standards of exposure to carbon monoxide, do not reveal the existence of a health hazard from this source in our city streets. The only individual who may possibly be exposed to a health hazard from inhaling street air containing automobile exhaust-gas is the traffic officer. This potential hazard may be minimized by diminishing the duration of exposure at the most congested traffic stations.

The Carbon Monoxide Committee formulated under the auspices of the American Chemical Society also plans to accumulate reliable information as to the distribution of carbon monoxide in various typical locations, as in commercial garages, in the open air near congested traffic and near loading platforms in stations.

One last word may be said as to the carbon-monxide content of the air in streets and garages. The public, according to students of the question, holds in its own hands the power of decidedly ameliorating the condition. Carbureters are commonly adjusted on the rich side; the combustible gas in the average automobile-exhaust from 1 gal. of gasoline contains nearly 30 per cent of the total heat in the original gasoline, according to a reliable estimate (52). This could be reduced to half that amount, thus saving about $200,000,000 in the Country's gasoline bill, and, with the greater completeness of combustion, reducing proportionately the carbon monoxide. The menace in garages is controllable by ventilation.

Physiological Effects of Small Concentrations of Carbon-Monoxide Gas

While the bibliography appended covers a number of phases of the physiological aspects of various degrees of carbon-monoxide concentration the following notes will refer only to the effects on human beings of such amounts as are likely to be due to automobile exhaust-gases.

As early as 1895 interest was shown in the subject in England, with the operation of the London Underground Railways. J. S. Haldane, a British authority, after investigating, gave his opinion that concentrations in the tunnel should not be permitted to exceed 1 part (116). Haldane, it must be borne in mind, contemplated a possible period of exposure sufficient for the blood to approach equilibrium with this concentration.

The next extensive investigations to be noted were those undertaken by the Bureau of Mines for the New York and New Jersey State Bridge and Tunnel Commissions (52). Four projects were carried out, in each of which the problem was viewed under a slightly different aspect. The first was designed to answer the specific question, what percentages of saturation of the blood with carbon monoxide cause appreciable discomfort in healthy adults sitting at rest or with activity similar to that of a person driving a car, for a period of 1 hr. Subjects of the test were confined in a gas-tight chamber of 226 cu. ft. capacity, into which measured quantities of pure carbon monoxide were introduced and mixed. Blood tests were made, the air in the lungs at the end of the exposure was examined, and the general feeling of the subject noted. The following table summarizes the data from 39 experiments on 9 men and 1 woman.

SUMMARIZED RESULTS OF EXPERIMENTS IN 226-CU. FT. CHAMBER

Concentration of CO in Air Breathed	Corresponding Equilibrium Value for the Blood	Found after 1 Hr.		
		In the Blood	Pulmonary Air	Headache
Parts in 10,000	Saturation, Per Cent	Saturation, Per Cent	Parts in 10,000	
2	23	11–12	....	None
4	36	14–22	1.30–1.36	None
6	47	16–26	1.0 –1.98	None or slight
8	53	26–34	1.7 –2.3	Distinct
10	58	38	....	Marked for several hours

On the basis of these data, the diagram shown in Fig. 4 was plotted. It shows the rate at which carbon monoxide is absorbed and the points at which physiological effects are felt.

The general conclusion drawn is that a maximum concentration of 4 parts is permissible in a tunnel for periods of exposure not exceeding 1 hr. for persons engaged in moderate exercise.

Findings Checked Under Practical Conditions

The second step was to check these results under circumstances more nearly resembling those of actual practice. In a brick building of approximately 12,000 cu. ft. capacity a Ford engine was operated under practically road driving conditions. The amounts of carbon monoxide liberated were controlled and measured. Groups of a dozen or more persons at a time sat or moved about in this chamber for periods of 1 hr. So long as the carbon-mon-

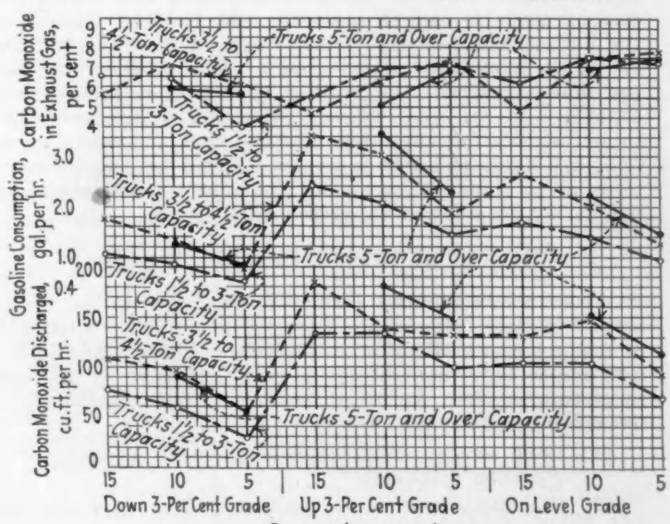


FIG. 3—CURVES SHOWING AVERAGE GASOLINE CONSUMPTION AND PER CENT AND QUANTITY OF CO IN EXHAUST GAS

The Data Were Obtained from Tests at the Bureau of Mines of Trucks of 1½ to 3-Ton Capacity Inclusive and of 5-Ton Capacity and Over, under Summer Conditions. They Represent the Average of Light and Full-Load Tests

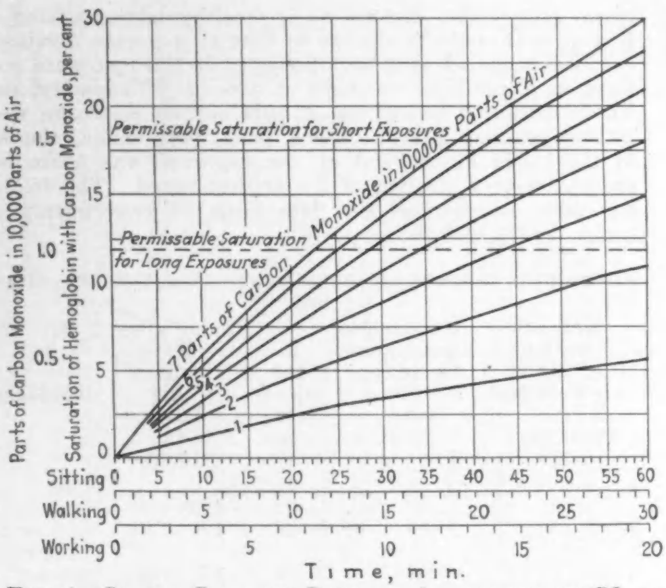


Fig. 4—Curves Showing Rate of Absorption of CO by the Blood

In the Tests on Which These Curves Were Based, Made for the New York and New Jersey State Bridge and Tunnel Commissions, Persons Were Exposed to Concentrations up to 7 Parts of CO in 10,000 Parts of Air, for Periods up to 1 Hr., During Rest (Sitting) and for Shorter Periods of Walking and Working

oxide-content standard worked out in the first project was not exceeded, no appreciable ill-effects were induced in any of the numerous subjects. Above this concentration, however, headache resulted in nearly all cases, and in some persons nausea and vomiting ensued.

Operating conditions were even more nearly approached in the third project carried out, where observations were made in the experimental vehicular tunnel in the Bureau of Mines Experimental Mine at Bruceton, Pa. Conditions representative of those expected to prevail in the Holland Tunnel were maintained. The investigators conducted 17 tests and made complete physiological examinations of observers, drivers and passengers. Tests were also made to determine whether temperatures and humidities, exceeding such as might occur in the Holland Tunnel on the hottest summer day, produce any increased absorption of carbon monoxide. Serving as a check on the conclusion previously reached, the results of the investigation lend authority to the final answer presented to the vehicular-tunnel ventilating engineers, namely, that no serious symptoms are likely to occur in exposures of 1 hr. to concentrations at or under 4 parts, but that the concentration can not safely be allowed to exceed this figure.

Hazard to Traffic Officers Studied

A return to controlled conditions was made in the fourth series of tests, planned to develop information applicable to traffic officers, laborers, automobile mechanics and others who might be either subject to long exposure or engaged in strenuous work for short periods. Four specific objectives were to determine the effect of

(1) Long exposure to concentrations of 4 parts of carbon monoxide

(2) Strenuous exercise for periods of 1 hr. in 4 parts of carbon monoxide

(3) High humidity and temperature on the absorption of carbon monoxide by blood, and on additional physiological changes produced

(4) Long exposure to concentrations of 2 and 3 parts respectively of carbon monoxide

The conclusions arrived at after observations made on persons in a gas-tight chamber of about 1000 cu. ft. capacity, with controllable concentrations of carbon monoxide, and under various conditions of work and rest are

(1) High temperature and humidity tend toward an increased saturation of the blood with carbon monoxide, a marked rise in body temperature, pulse rate, and respiration, and an earlier occurrence of symptoms

(2) Strenuous exercise causes an increase in the absorption of carbon monoxide by the blood, and an earlier occurrence of symptoms

(3) Exposures of 2 to 2½ hr. to 4 parts of carbon monoxide will cause an accumulation of symptoms varying from decreased efficiency to basal headaches and nausea

(4) An exposure to 2 parts of carbon monoxide gives mild symptoms at the end of 6 hr., and an exposure to 3 parts gives similar symptoms in from 2½ to 3 hr.

(5) The effects of 4 parts of carbon monoxide under various conditions may be summarized as follows, according to the experiments carried out by the authors:

Condition	Period, Hr.	Symptoms
No exercise	1	No effect
No exercise	1½	Mild symptoms, no serious effect
Mild exercise	1	Mild symptoms, no serious effect
Strenuous exercise	½	Mild symptoms, no serious effect
No exercise, in high temperature and humidity	1	Mild symptoms, no serious effect

The Bureau of Mines has recently completed another investigation intended to throw further light on this phase of the carbon-monoxide question. In this were studied the physiological effects of long daily exposures, say from 5 to 6 hr., to exhaust gas-air mixtures containing 2, 3 and 4 parts of carbon monoxide. The tests were in progress 7 days a week for a period of 12 weeks, so that judgment could be made as to permitted periods of exposure for traffic officers. A report is at present being prepared.

On the basis of various experiments, Yandell Henderson and H. W. Haggard (220) have made the following summation applicable to periods of not more than a few hours:

> When the time is measured in hours and the concentration of carbon monoxide is expressed in parts in 10,000 of air, the physiologic effect when time multiplied by concentration equals 3 is not perceptible; 6, just perceptible; 9, headache and nausea; 15, dangerous.

Findings of Academy of Medicine

A special subcommittee of the Committee on Public Health Relations of the New York Academy of Medicine recently made a survey of the literature touching on carbon-monoxide poisoning and the relation to it of automobile exhaust-gas (233). The following conclusions as to the physiological dangers are of special interest:

(1) In spite of the great amount of study given to carbon monoxide and its effects upon life, there is no agreement among investigators as to the fundamental nature of the problem. One group maintains that the poisonous manifestations of the gas are due solely to oxygen deprivation caused by the affinity of carbon monoxide for hemoglobin, while another holds that the gas has a specific toxic action on the nerve tissues and cells. Some claim that the gas is promptly dissociated or thrown off by the hemoglobin as soon as the individual

breathes pure air; others feel that the combination of carbon monoxide and hemoglobin is a stable compound that is never broken down and is not discharged until the blood corpuscle meets its death. Whether carbon-monoxide poisoning is cumulative in its effect is a question. The weight of present-day opinion is in favor of the point of view that the poisonous manifestations of the carbon monoxide are due solely to anoxemia.

(2) The effects upon the human system of frequent exposure to very low concentrations of carbon monoxide in the inspired air need detailed study. The many now disputed questions as to the action of the gas require settling, particularly in relation to the pollution of the air by the automobile exhaust-gas.

(3) There is need of effective safeguarding of the health of those exposed to the dangers of carbon monoxide in industry and elsewhere by State and municipal authorities.

Action of Ozone on Carbon Monoxide

A specific that has been suggested for reducing any carbon-monoxide hazard in garages is the use of electrically generated ozone, either for the elimination of carbon monoxide through chemical reaction, or for its beneficial effect on human beings. To form a proper judgment on this expedient requires an examination of three angles of the question: the chemical, the physiological, and the actual experimental use of ozone in garages.

Twelve articles were found dealing with the chemical reaction of ozone with carbon monoxide. The first investigation to reach publication seems to have been that made in 1876 by Ira Remsen and Mase S. Southworth (243).

In this study pure carbon-monoxide and the ozonized oxygen were caused to meet in a flask, the inside of which was moist. The mixture of the two gases and any carbon dioxide which might have been formed were then passed together into lime-water, contained in a cylinder, the lime-water being protected from the influence of the carbon dioxide of the air by the potassic hydroxide contained in the last cylinder. No trace of a precipitate could be detected in the last cylinder, containing lime-water. A further step was to modify the apparatus to cause it to act in sunlight. In summarizing the results of their work, the authors made the following unequivocal statement: "We hence are in a position to assert positively that carbon monoxide is not oxidized by ozone."

Three years later the French scientist Berthelot observed (244), on passing a silent discharge through a mixture of carbon monoxide and oxygen in one of his ozonizer tubes, that the change to carbon dioxide was nearly complete after the discharge had passed for a long time. The failure of Berthelot to secure complete oxidation of carbon monoxide in the silent discharge is said to indicate that the dioxide is broken up to a slight extent; but that with a concentration of carbon dioxide less than 1 per cent its decomposition is negligible.

A. R. Leeds and E. Baumann were the next contributors to the study. The former (245) allowed a mixture of 2500 cc. (152.56 cu. in.) of air and 0.04 mg. of ozone, made by contact of the air with moist phosphorus, to stand for 18 hr. At the end of this time 14 mg. of carbon dioxide had been formed; or 6.9 cc. (0.42107 cu. in.) of carbon dioxide had been formed from 2500 cc. (152.56 cu. in.) of carbon monoxide; in other words, about 0.25 per cent of the carbon monoxide had been oxidized. Confirming these results, Baumann (246) in one experiment passed a mixture of 30 liters (1.0594 cu. ft.) of air and 2.45 liters (148.608 cu. in.) of carbon monoxide through moist phosphorus for 12 hr. About 1.3 per cent of the carbon monoxide was oxidized.

The early experimenter, Remsen, returned to his subject again in a published report in 1882 (247). "If in any gaseous mixture there is ozone and no nascent oxygen, carbon monoxide will not be oxidized by it," he states. "Having proved beyond a doubt that carbon monoxide is not oxidized by ozone at the ordinary temperature, it remained to determine at what temperature the oxidation is effected."

Previous experiments, he points out, led to what seemed to him an astonishing result, viz., that carbon monoxide is not oxidized by ozone even at the temperature at which the ozone is transformed into oxygen. For various reasons the early experiments were left in a somewhat unsatisfactory state, but they were repeated at Remsen's suggestion by E. H. Keiser. "Every precaution was taken to avoid error," Remsen concludes, "and the result reached fully confirms the conclusion just stated."

Again a year later Remsen and Keiser gave the results of further investigation of carbon-monoxide reactions (248). They repeated the experiments of Leeds and Baumann and were brought to a conclusion directly opposed to that recorded by those investigators. They point out some methods of procedure in the earlier research that they regarded as erroneous, and conclude,

> Whatever the sources of error in Baumann's experiments may have been, we are confident that a repetition with the precautions taken by us will show him that the conclusion is wrong.

After this period of concentrated interest, 20 years elapsed before the next publication on the subject. Then W. A. Jones (249) told of passing pure air and carbon monoxide over carefully purified phosphorus, and always finding carbon dioxide in the barium-hydroxide absorbing solution. Another series of experiments with strong ozone made with an electric ozonizer showed, he says, that the oxidizing power of ozone varies with the temperature and the concentration. The action of ozone on carbon monoxide at room temperature was found to be appreciable if the concentration of the ozone was high.

Repeating Jones' experiments, C. E. Waters (251) found that,

> Although ozone does not act on carbon monoxide as readily as we should expect from its apparent unsaturation, still it does cause some oxidation to carbon dioxide, depending on the amount of ozone present in the oxygen. And, further, the oxidation does not take place to an appreciable extent at the ordinary temperature.

Clausmann, according to a report published in 1910 (256), prepared ozone of a very high concentration, 200 mg. (3.0864 grains) per liter (61.023 cu. in.), and allowed it to react with carbon monoxide. If the gases were dry and kept in the dark, only 0.88 per cent of the carbon monoxide was oxidized in 8 days, while in the sunlight 2.83 per cent was oxidized during the same time. If the gases contained a little moisture, at the end of 7 hr. a 2.5-per cent oxidation occurred; and in 24 hr., 3.67 per cent. In none of these experiments was the ozone completely decomposed. The conclusion drawn from this investigation is that carbon monoxide is slowly oxidized in the presence of a high concentration of dry ozone and that light and moisture accelerate the reaction, indicating that decomposing ozone is the active agent.

Investigations on the removal of carbon monoxide from air were carried on at the American University Experiment Station and at cooperating laboratories during 1917 and 1918. In an account of this work (257) Arthur B. Lamb, William C. Bray and J. C. W. Frazer refer to the use of ozone, and, after summarizing previous research, conclude:

> The data obtained by these investigators all indicate that the reaction occurs at best only in stoichiometric proportions, that is, a molecule of ozone is consumed for every molecule of carbon monoxide

oxidized. So long as such is the case, this method of eliminating carbon monoxide appears hardly feasible on account of the large and expensive electrical installation required to produce the ozone. Thus, on this basis, to purify 100,000 cu. ft. per hr. of air containing 0.1 per cent carbon monoxide would require 200 kw. per hr. of electric energy, with the most efficient ozonizer.

A year later, Arthur B. Ray and F. O. Anderegg published an account of experimental work begun in July, 1917, by the former under the direction of W. K. Lewis and R. E. Wilson as a part of the war-gas investigations conducted by the Bureau of Mines, and later continued by the latter under the direction of Lieut.-Col. A. B. Lamb (258). The particular topic under investigation was the oxidation of carbon monoxide by passage with oxygen or air through the silent discharge and over ozone-decomposing catalysts. Two conclusions drawn are pertinent to this issue:

(1) No appreciable oxidation of carbon monoxide present in small amounts in air or oxygen is affected by a low concentration of ozone unless the ozone is decomposed by special catalysts.

(2) Until a much more efficient form of ozonizer is developed, the oxidation of carbon monoxide by electrical means will not be commercially practical.

Carroll M. Salls, chemical engineer, bureau of industrial hygiene, New York State Department of Labor, in a recent article (282) to be referred to again later, sums up previous investigations and asks:

> Will ozone actually oxidize carbon monoxide? The chemists who have investigated the reaction do not agree. If there is any reaction at all, it is so slow and ill defined that some deny its existence. Others have found evidence of a partial reaction. A careful review of the work of these chemists leads us to the conclusion that ozone oxidizes carbon monoxide at a rate so slow that it is probably of no use in garage ventilation for the purpose of destroying carbon monoxide. The exhaust gas from the engines would be removed from the room by ordinary diffusion through doors and windows at a faster rate than the ozone could oxidize it.

Physiological Effect of Ozone on Human Body

The famous Scotch verdict, "Not proven," seems aptly to characterize the cases for and against the beneficial effect on human health of ozone in ventilation (Ozone concentrations usually are defined as 1 part of ozone to 1,000,000 parts of air, and this practice will be hereinafter followed unless otherwise specified.)

Leonard Hill and Martin Flack, after certain experiments on animals and human beings, and a review of previous literature, lay down in an article published in 1911 (259) six dicta governing the use of ozone in ventilation:

(1) Ozone is a powerful deodorizer; it masks rather than destroys smells.

(2) A concentration as little as 1 part is irritating to the respiratory tract. Exposure for 2 hr. to a concentration of 15 to 20 parts is not without risk to life. The irritative effect and the discomfort produced thereby, cough and headache, give ample warning.

(3) The respiratory metabolism is reduced by ozone in concentrations even less than 1 part.

(4) The beneficial effect of ozone obtained by the ozone ventilating systems is to be explained by its effect on the nervous system. By exciting the olfactory nerves and those of the respiratory tract and skin, it may relieve the monotony of close air, and the smell of tube railways, in cold meat-stores, hide stores and other trades.

(5) There is no harm in breathing weak concentrations of ozone, such as can be scarcely sensed by a keen sense of smell.

(6) Ozone in somewhat high concentrations (1 part) may have some value as a therapeutic agent if inhaled for brief periods; by irritating the respiratory tract it may act as a blister or fomentation and bring more blood and tissue lymph to the part.

American Medical Association Tests

The troubled waters of controversy were stirred up 2 years later by the simultaneous publication of the reports of two investigations into the efficacy of ozone in ventilation. Drs. E. O. Jordan and A. J. Carlson, of Chicago, under a grant of funds from the American Medical Association, conducted the first (260); and Dr. W. A. Sawyer, director of the hygienic laboratory of the California Board of Health at Berkeley, assisted by H. L. Beckwith and E. M. Scolfield, bacteriologists, the second (261).

In the Chicago study, five types of test were made. First, to test the action on bacteria, culture-soaked threads and filter-paper strips, variously prepared, were exposed for periods up to 5 hr. to ozone concentrations of from 3 to 4.6 parts. No sure germicidal action could be seen from the varying results. Second, a series of tests with air bacteria revealed after 24 hr. of incubation such slight and irregular variation of bacterial colonies that no effect of the ozone could be deduced. A third subject investigated was the deodorizing properties of ozone. Ozone, it was concluded, did not destroy but only masked odors, and for even this effect in the case of some odors concentrations of as much as 2 to 5 parts are necessary. In the fourth project, tests were made on small mammals with ozone concentrations thought by the investigators to represent those that might be used in experimental therapeutics; which caused harm of varying degrees to the subjects. Breathing mixtures up to 10 parts for not less than 15 min. total time produced, in the human subjects, sore throat which persisted for 2 or 3 days and was occasionally accompanied by pain in the chest. Four cats, 4 rabbits, 6 guinea pigs and 12 rats were the subjects of the last tests, conducted to ascertain the effect of such ozone concentrations as are used in ventilation. The concentrations varied from 1 part to a dilution just detectable by odor. All the animals exhibited an increase in weight, but practically the same in the control period without ozone as during the ozone exposure.

In concluding, the authors question the desirability of masking odors, since the unpleasant odor is the danger signal of poor ventilation. They also question whether the ozone tang is of any more beneficial or any more physiologic effect than a whiff of smelling-salts or a puff of a cigaret.

The California investigation consisted of a few experiments with two ozone machines designed for use in ventilation. Animals and bacteria were exposed to the products of the same machines, but in every case the animals were dead before the bacteria were rendered sterile.

A number of critical reviews of these two articles appeared in later publications. Quotations from one of the more extensive of these, by J. C. Olsen and William H. Ulrich, serve to indicate their general nature (273).

> A number of errors in the methods used in the experiments given in these articles have been noted and these seem so serious and the articles have been so widely quoted that it seems desirable to correct the misapprehensions which have been produced. . . .
>
> If the facts presented in this (Jordan and Carlson) paper are properly interpreted they will be found to

be in accordance with the view that ozone is a powerful disinfectant and deodorizing substance, which, in suitable concentration, is without any injurious effects whatever.

With reference to the alleged harmful effects of ozone, no single instance of harm to a person from the proper use of ozone in ventilation has been published, but all adverse opinions have been deduced by inference, as in the paper by Jordan and Carlson, from experiments performed with very high concentrations, while all efforts to produce harm experimentally with weak ozone have failed.

Charles P. Steinmetz, another critic of the findings (263), succinctly summed up the state of the art in the following words:

> In the literature of ozone at present there seems to be practically no statement which is not flatly contradicted by exactly the opposite statement made by equally high authority.

Let us give the authors, E. O. Jordan and A. J. Carlson, the last word. In a blanket reply (272) to the comments on their work, they say:

> Ozone in ventilation does not make the air pure in any sense. It has not yet been shown that the concentration of ozone which can obtain in ventilation has any directly favorable or unfavorable action on man or animals. But one fact seems significant, namely, as soon as we reach a concentration of ozone that has a demonstrable physiologic action on man, this action is definitely injurious.

Foreign Lecturers on Ozone

To remove to another country the arena of debate, Professor Czaplewski, lecturing (270) at the 9th Congress for Heating and Ventilating at Cologne, 1913, is reported to have concluded:

(1) As regards the air-purifying properties claimed for ozone we need not count on a destruction of bacteria in the air by ozone, or their destruction on the walls of rooms, or on objects in the room. There is no oxidation of the organic dust particles. There is, however, a positive effect on certain scents and the odors given off by the same. Some odors are destroyed, others are weakened

(2) The effects of ozone on man depend on the concentration. In small and weak concentrations the effects are agreeable and are found to be refreshing and entirely without danger. In stronger concentrations the ozone irritates the mucous membranes and especially the respiratory tracts

(3) Whether the cases of death in animals and sickening effects in man are due to the ozone alone is a matter of doubt.

(4) For ventilation with people in the rooms only the weakest concentrations are to be used, such as lead to no complaints by the people.

(5) The peculiar contradictions between the favorable practical results and the results of many laboratory experiments should be cleared up by further research

At the same meeting Ludwig von Kupffer (269) recited some experiences tending to prove the efficacy of ozone in destroying or counteracting odors and retarding fungus growth, and quoted testimonials in favor of the use of ozonators furnished by their users.

Milton W. Franklin, the translator of the Czaplewski article, himself stated (266) in another publication:

(1) Ozone destroys the odors of certain foodstuffs and other organic sources of odor. (He denied specifically that only a masking effect is produced).

(2) Ozone is in no sense poisonous, though in great concentrations it is capable of causing local irritation of the mucous membranes with which it comes in contact

(3) Prolonged ozonation is capable of ridding, at least in a measure, the atmosphere of food-storage rooms of germ life, probably through rendering it an unsuitable medium for their support

(4) The analogy between laboratory tests and actual practical applications is often so obscure and replete with modifying factors that the extremest care must be exercised in applying the results of experimental observations to practice.

A. Vosmaer, writing a little later on the use of ozone (268), emphasized that for the purpose of ventilation the concentration should be low, certainly not more than 1 in 1,000,000 parts of air and preferably something like 1 in 10,000,000 parts of air when intended for continuous breathing. The benefits following in the wake of ozone were said to be stimulated breathing, due to lack of odor, and increased percentage of oxyhemoglobin in the blood. In a book written two years later Vosmaer repeats this dictum as to the desirable concentration of ozone (274).

The results of seven years' experience with ozone, for the most part in the Pittsburgh Homeopathic Hospital, constitute the subject matter for the last publication (271) noted in this general period. The author found that in dry air a concentration of 3 had no appreciable effect on bacteria, but a slight inhibition was noted at a concentration of 6; in moist air, a decided inhibitory effect was observed at 3, and bacteria were killed at 6. In this connection he pointed out that a person can stay only a very few seconds in a room filled with ozone at a concentration of 3 or more. Further, he stated, ozone actually destroys all organic odors and some inorganic ones. The benefit of ozone treatments he attributed to raising the resistance of the subject, not destroying germs, as ozone strong enough to kill bacteria would be disagreeable and even harmful to the patient.

Effects of Various Ozone Concentrations

Extensive tests and a search through the literature combined to give two authors of 7 years later, E. Vernon Hall and John J. Aeberly (276), the material for the following table:

EFFECTS OF VARIOUS CONCENTRATIONS OF OZONE AS GIVEN BY DIFFERENT AUTHORITIES

Ozone Concentration, Parts per 1,000,000	Effect	Authority
0.01	Barely distinguishable to keen sense of smell	Hill and Aeberly
0.02	Concentration found in nature at altitude of 4000 ft.	Thierry
0.04	Found in nature at an altitude of 12,000 ft.	Thierry
0.06	Clearly distinguishable to sense of smell	Hill and Aeberly
0.48	Cheese-cloth impregnated with tobacco odor deodorized in 9 min., cheviot in 29 min., satin in 18 min., and duck in 6 min.	Franklin
1.00	Irritating to mucous membrane on long exposure	Hill and Aeberly
2.30	Materially reduced odor of casein	Franklin

Ozone Concentration, Parts per 1,000,000	Effect	Authority
3.00	Irritating to mucous membrane on continuous exposure for 2 hr.	Hill and Aeberly
4.00	Hastens the rate of disappearance of odor due to decomposing meats	Jordan and Carlson
5.60	Destroys odor of casein, leaving an excess of ozone	Franklin
6.00	Causes coughing after moderate exercise	Hill and Aeberly
9.00	No effect on bacteria exposed for 3 hr.	Jordan and Carlson
10.00	Exposure for 15 min. causes sore throat	Jordan and Carlson
20.00	Exposure for 2 hr. may prove fatal	Hill and Flack
137.00	Preserved eggs 50 days without detecting mildew	Franklin
245.00	Reduces tobacco smoke (marked clearing of dense smoke noted within 1 hr.)	Franklin
500.00	Required for germicidal purpose	Rideal

The reported improvement in the health of workmen in the London tubes since the installation of ozone ventilating equipment is grouped by the authors with the considerable amount of evidence of this kind, hearsay and more or less untrustworthy, to the effect that ozone in low concentrations exerts a favorable effect on persons subjected to it over extended periods of time. No evidence, they concede, has been developed to show that low concentrations are harmful; on the contrary, ozone is thought to be a valuable deodorant, and so, indirectly, to cause deeper breathing and more thorough aeration of the lungs and blood.

Ozone for Use in Garage Ventilation

The use of ozone in the ventilation of the St. Louis schools leads the writer of one report, Edwin S. Hallett (275), to the following enthusiastic endorsement:

> There is no doubt whatever of the beneficial effect of ozone upon the health of the children as used in the St. Louis schools, as evidenced by the gain in weight and the very perceptible gain in ruddy color in the faces of all the children and especially those who are pale and anæmic. . . .
>
> The tests in the St. Louis schools prove that the air as now treated is better in every respect than the outside air.

While conceding that the effect of low concentrations of ozone on the human body requires further study and investigation (277), Henry Hamilton, Jr., states:

> Even where ozone is used in concentrations so low that no oxidizing effect on the odorous substances is produced, the masking effect alone results beneficially . . . thus improving the air conditions and giving that freshness or tang so noticeably absent where mechanical ventilation is employed. This over an extended period of time has an inhibitive effect on the growth of bacteria and mold.

The last of the historical references are two articles by Frank E. Hartman. In the first (278), the following statements are made:

> In sufficient concentrations (say 15 parts) ozone is an exceedingly active respiratory irritant, and further attacks the mucous membranes of the eyes, nose and bucal cavities.
>
> In low concentrations it is specifically remedial for chronic anæmia, since small quantities of ozone increase the hemoglobin or red corpuscles of the blood. . . .
>
> Personally, I do not believe that ozone, per se, is stimulating, but I do believe that it is remedial and has a specific value in the atmosphere that we breathe. I believe that the function of ozone is that of a scavenger; it keeps our air pure so that we will involuntarily breathe properly.

In the later publication (279), the quantity of ozone required for ventilating purposes is given as of the order of 0.01 to 0.1 part per 1,000,000 by volume. The concentration necessary for germicidal action (1 per cent) in air having a normal vapor-content is thought to be far beyond the respirable limit of this gas.

Current Investigations

A recent statement of Dr. May R. Mayers, bureau of industrial hygiene, New York State Department of Labor, who has investigated ozone as an aid to ventilation in garages and hospitals, will serve to bring this summary into the realm of current history. She sought, in an investigation outlined in the *Industrial Hygiene Bulletin* (281), the answer to two questions:

(1) Does exposure to ozone tend to cause a rise in the hemoglobin of the blood, thereby assisting the body in maintaining a normal oxygen-carrying capacity despite the fact that some of the hemoglobin is tied up with carbon monoxide and so cannot adequately fulfill its normal oxygen-carrying function?

(2) Does the presence of ozone in the air tend to increase the partial pressure of the oxygen in the alveolar air, thus making it more available to the tissues?

A letter from Dr. Mayers, under date of Jan. 12, 1928, gives the following preliminary information on the results of the tests:

> We have installed an ozone machine in the nursery and childs' hospital. After running a series of "normals," we came to the conclusion that exposure to ozone does *not* increase the hemoglobin content of the blood. Further calculations as to the relative partial pressures of oxygen, ozone and carbon monoxide in the alveolar air have convinced us that any beneficial results from exposure to ozone could not be accounted for on the basis of an increase in the partial pressure of oxygen in the alveolar air, in the presence of ozone.
>
> The whole subject is still a mystery, therefore, as far as we have gone. Nevertheless, we are very loath, in view of the clinical evidence in its favor, to completely discard ozone, and say there is nothing to it, just because we cannot as yet explain its action. It may very well be that it has no value whatever, but we feel that this has not yet been conclusively proved.

Ozone for Use in Garage Ventilation

In judging, *a priori*, the probable effectiveness of ozone in garage ventilation, the following points covered in a summary way in the above discussion should be considered:

(1) Does ozone react chemically with carbon monoxide to form the harmless carbon-dioxide?

(2) What concentrations of ozone are needed, if this reaction does occur, to destroy such concentrations of carbon monoxide as are dangerous to breathe?

(3) What would be the effects of such ozone concentrations on human beings?

Few scientifically conducted tests on the effectiveness of ozonators in garage ventilation are reported in the published literature. Reference is again made to the letter

from Dr. Mayers, under whose direction research on this topic has been carried out.

> We have been working with ozone for some time in an attempt to determine whether or not its popularity among the workers in our service-stations can be explained on any but psychological lines. To date, I am afraid we have found nothing in its favor, but we are continuing our investigation, nevertheless.

Dr. Carroll M. Salls, chemical engineer, bureau of industrial hygiene, New York State Department of Labor, has published the results of a study of the specific problem of ozone in garage ventilation (282). In the tests a 10-cu.m. (353.1 cu. ft.) gas-chamber was filled with air thought to be representative of garage atmospheric conditions, containing about 13 parts of carbon monoxide. An 18-in. circulating fan and a 1.92-gm. per min. ozonator were operated in the chamber. Three air-samples were withdrawn from the chamber at 10-min. intervals, the ozonator was started, and sampling continued at 10-min. intervals, eight samples being so taken. Fig. 5 shows the shape of the curve, from which it is seen that the actual concentration of carbon monoxide, because of diffusion from the gas chamber, gradually decreased at the same rate before as after starting the ozonator. The curve is not a straight line because increasingly large quantities of air are required to effect the same ratio of dilution as the concentration of carbon monoxide becomes smaller.

The report continues:

> In order further to confirm our results, tests were made of the atmosphere in service-stations where ozonators were in operation. As was expected, appreciable amounts of carbon monoxide were found, and in two automobile repair-shops quantities as high as 3 and 4 parts per 10,000 were found.
>
> Even though carbon monoxide were promptly destroyed by ozone, a simple calculation shows that four ozonators would be required to destroy the carbon monoxide from each engine in operation. . . .
>
> Even though the maximum recommended concentration of 5 parts of ozone per 1,000,000 were installed, that concentration could not react with more than 15 parts of carbon monoxide; and it is well known that at least three times this quantity of carbon monoxide can easily be tolerated.

In view of these facts it is difficult to explain the very beneficial results reported by some employes and proprietors. The psychologic effect of a preventive measure that they can see and smell may have something to do with it. If there is any real physiologic effect of the ozone which balances the effect of the carbon monoxide within the human body, that effect is yet a mystery which future medical research must solve. Ozone has been recommended in the practice of medicine for a variety of ailments, achieving apparently a degree of success in some cases, and it is just possible that future research will show that ozone is a valuable treatment for carbon-monoxide poisoning.

But from the practical viewpoint it is far better to remove a poisonous gas by adequate ventilation than to depend on the inhalation of a still more poisonous gas in the hope of bringing about a problematic physiologic reaction.

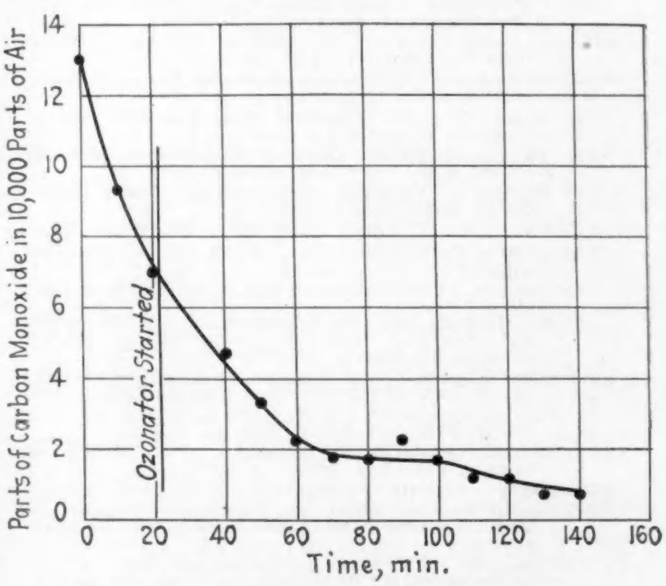


Fig. 5—Ozonator Test on Carbon Monoxide

In Making This Test the Bureau of Industrial Hygiene, New York State Department of Labor, Used the Sayers-Yant Pyrotannic Method. When the Sampling Was Started, the Chamber Contained 13 Parts of Carbon Monoxide. Samples of Air Were Withdrawn and Analyzed at 10-Min. Intervals. The Ozonator Was Started after the Third Sample Was Withdrawn. Note that the Shape of the Curve Is Not Changed by Starting the Ozonator

(*a*) General Research on Carbon Monoxide

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(2) Asphyxie par le Gas Oxide de Carbone et par le Gaz Hydrogène Carboné. Dictionaire des Sciences Médicales, Vol. 2, p. 390.

(3) Moyen de Reconnaitre la Présence de l'Oxyde de Carbone dans l'Air Confiné; by Jean. Annales de Chimie Analytique, Vol. 3, p. 260.

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(10) Iodine-Pentoxide Method for Determining Carbon Monoxide in Low Concentrations of Air; by M. C. Teague. Appendix 4, Report of Tunnel Gas Investigation, Problem No. 2, Physiological Effects of Exhaust Gases, 1921, p. 203.

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(15) Carbon-Monoxide Hazards from House Heaters Burning Natural Gas; by G. W. Jones, L. B. Berger and W. F. Holbrook. Bureau of Mines Technical Paper No. 337, 1923.

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Logic and Language

IN a way logic and language may be regarded as double aspects of the same thing. John Stuart Mill somewhere remarks that the structure of every sentence is a lesson in logic. For language provides the forms in which thought must of necessity be molded.

A curious inquirer might be led to raise a difficult question: Does the mind become logical because it acquires language, or does language become logical because logic is inherent in the nature of the mind? If the latter possibility is accepted, then language is merely a reflection of an innate logical necessity that exists independently of any forms of expression. But if the former possibility be preferred, then logic is practically equivalent to language, that is, logic is no more than the customary ways of expressing thought. What is expressed in accordance with the established habits of expression in the language thus seems to us reasonable and logical, and these habits give to us an assurance of the existence of an ordered intellectual universe.

Without attempting to prove that either the one or the other of these suppositions is correct, we may dwell for a moment on the notion of the intimate connection between logic and language. For, if the theory of innate logical ideas in the mind is correct, we may point out that the only way the existence of these ideas can be made comprehensible, whether by a thinker to himself or to other persons, is by means of language. Imageless thought is an alluring hope, but one the expression of which the human mind has not yet realized. We can think only by the aid of forms and symbols of some kind, and language is preeminently the medium through which mind must know itself.

On the other hand, if logic is nothing more than the sum of the customary habits of the language, which long experience has made us feel to be the natural and necessary ways of thinking, it loses nothing of its significance so far as the life of man is concerned. Logic may be man-made, it may be the child of man's experimentations in the art of self-expression. But, if this is so, logic is as much a necessity in human life as it would be if we could think of it as coming down in the form of a pure gift from heaven. For a sense of order, of intelligible sequence and relationships is one of the constant demands of all human existence, not only among the learned, but with the unlearned as well. And whether we elect to denote the source from which this sense of order comes to us as logic or as language makes very little difference. In the work of every-day practical experience they are the same.

Whatever logic is, therefore, we may agree upon the first general proposition that language is logical. It is through language that our desire for intelligibility is satisfied. When language becomes unintelligible, when it fails to express a comprehensible sequence of ideas, it ceases to be language. It becomes then merely a succession of meaningless syllables.—From The Knowledge of English, by George Phillip Krapp.

Operation and Maintenance

Brake-Lining Failures

Suggestions Made Regarding the Maintenance of Satisfactory Braking Service

THE principal requirements of a satisfactory brake-lining are length of life, quietness, consistent braking efficiency throughout a wide range of temperature, the facility with which the lining can be installed, and its retardation of the speed of a vehicle with maximum efficiency, according to John H. Watrous, of Ferodo & Asbestos, Inc., who presented a paper on Causes of Brake-Lining Failure at a meeting of the Southern California Section.

From the viewpoint of the fleet operator, Mr. Watrous said in part that it is naturally the aim of the brake-lining manufacturer to produce a product having universal application as nearly as possible, one suitable for use under a great variety of climatic, operating and road conditions. This problem is made more difficult because of the great variety of braking installations on the vehicles already in service in the average large fleet. In addition, the introduction of four-wheel brakes has increased the burden of service on older models equipped with two-wheel brakes which operate on the same highways. Therefore, the fleet operator is faced with the problem of using, to the best advantage possible, braking systems which may be grossly inadequate for present-day traffic.

Failure of a brake-lining to stop a vehicle properly generally is caused by a combination of the following factors: (*a*) too limited a braking area; (*b*) insufficient unit pressure; (*c*) too low a coefficient of friction in the lining itself; and (*d*) lubrication on the surface of the lining. An area of 1 sq. in. of brake-lining surface should be provided for every 35 lb. of vehicle load. Linings perform best with a unit pressure not less than 15 lb. per sq. in.

Trouble due to lubrication is aggravated by the varying powers of absorption of different linings. Tests show a variation in this respect from practically zero to as high as 15 per cent. In all cases in which water is present between the frictional surfaces, it has a lubricating effect on both drums and lining and temporarily lowers the coefficient of friction. The greater the absorption power of the lining is, the longer will this condition persist. If a lining is impervious to water, it is only necessary to wipe off the surface water, and this is accomplished in actual service at a much earlier stage than when the water has penetrated the lining. In the latter case, frictional heat is needed to dry out the lining.

Unsatisfactory Wear

Failure of brake-lining to wear satisfactorily is due to excessive and unnecessary generation of heat on account of dragging brakes or because of too limited braking-area; to grease or oil on the lining; to drum scoring; and to abuse by drivers.

Many external-band brakes do not conform to the shape of the drum and, when released, do not spring back to their original shape. This can be remedied by shaping the bands on dummy drums and replacing defective bands with bands made from spring steel. Dragging of the brakes is caused also by springs which lose their temper and do not function in their release, particularly on transmission brakes, where high temperatures and vibration have previously influenced this condition; to lack of lubrication and cleanness of the moving parts of the braking system; to broken release springs, particularly on internal brakes; and to too fine an adjustment for clearance, with no allowance for drum expansion. Proper clearance may be limited by conditions in the design of the brake linkage.

Rapid wear due to too limited braking area is aggravated by the overloading of trucks without provision for the proper increase in braking area and, in cases in which smaller drums are used, due to a change in tire equipment. It is not reasonable to expect a lining to perform properly with a proportion of 100 lb. of vehicle weight per square inch of braking surface when, fundamentally, it was designed to function properly at 35 lb. per sq. in. of lining. Overloading also causes changes in spring position, which may throw the whole braking linkage out of line.

Grease or oil on the lining does not necessarily affect the actual wear-factor, but it makes the braking action erratic and is probably the most frequent cause necessitating relining on certain types of brake. This is especially true in the case of some individuals who are careless in the use of high-pressure greasing equipment in some service stations. Fleet owners have improved this condition by the use of piano felt to replace ordinary felt and, in the latest models, greatly improved grease retainers are used.

It appears from experiment that virtually all linings have been unfairly blamed for drum scoring. Relatively few linings contain any ingredient, such as silicate of soda, which could basically be responsible. Scoring has usually been traceable to the depositing of molecules of steel on the surface of the lining, at high temperatures, during the more rapid wear of low-carbon-steel drums. These molecules, under frictional heat, weld themselves into small cutting-tools, usually harder than the drum itself. This condition is greatly influenced by the abrasive action of stone and grit embedded between the lining and the drum. It is further influenced by too drastically burning-in new lining, when its surface is more receptive of these particles, and before a full braking surface is obtained. In the opinion of Mr. Watrous, a great percentage of scoring in started during the first few days of use, if the lining is not properly installed and is abused by the driver before it is properly seated to the brake-band or brake-shoes.

Recently, the carbon content of pressed-steel drums has been raised by many car builders, and more suitable drums are being supplied for heavy-duty work. For heavy duty, good close-grained cast-iron drums or hard cast-steel drums are most satisfactory. Under very severe braking conditions on the Ridge Route in California, cast-iron drums on motorcoaches, used with asbestos lining, have been in service for the last 6 months; but standard drums score very rapidly in this type of service. Naturally, the troubles incident to temperature rise will still occur if a glaze forms on the lining used; but, apparently, the mass of metal in this type of drum assists greatly in dissipating the heat generated, and the lining life is prolonged.

In any severe-service condition, in which the drums score and the linings roughen instead of taking a smooth polish during wear, greatly increased lining life and lowered braking costs can be secured by using suitable drums. Some success has also been obtained in lighter service by the rebanding of worn-out pressed-steel drums, using high-carbon-steel strips. If the vehicle owner would be particular in the selection of responsible dealers or brake

stations for installing lining, and would bring his car in occasionally for checking and adjusting, greatly increased life of brake-linings would be assured. Mr. Watrous believes that linings treated with pure vegetable gums having high heat-resisting qualities give the most uniform coefficient of friction through normal and abnormal braking temperatures.

Causes of Brake Squeak

Fundamentally, brake squeak is the result of vibration, and possibly 90 per cent of squeaky brakes are the result of mechanical troubles. Brake-linings can influence brake squeaks primarily for the following reasons:

(1) A non-uniform coefficient of friction on the same surface, when a part of the segment glazes

(2) The lining is not completely and uniformly impregnated, so that the coefficient of friction varies after the wear has passed the surface coating of the lining

(3) Irregular high spots on the surface of the lining, preventing 100-per cent contact. Road grit, protruding rivet-heads, and the edges of metal shoes also prevent full contact and influence squeaking

(4) Too high a coefficient of friction in the lining itself may cause squeak, in the opinion of some brake designers and brake-lining manufacturers

The typical mechanical troubles are wrong adjustment, irregular unit pressure on parts of the braking surface, lack of rigidity both of shoes and of drums, use of drums that are out of round, and wheels having loose bearings.

Extending Brake and Lining Life

The following practice is recommended by Mr. Watrous to prolong the life of brake-lining:

(1) Keep the braking surface clean

(2) Wash off grit and abrasive material periodically

(3) Avoid the use of dope or surface coatings

(4) Keep temperatures down by avoiding overloading

(5) Use the proper drums for severe-service conditions

(6) Watch adjustments to prevent dragging brakes

(7) Give the lining a chance to become thoroughly seated before using it too drastically

(8) Do not burn-in a lining at high temperatures; instead, hammer or buff down the high spots around the rivet holes, rub a small quantity of graphite on the lining surface, and warm up the brake only enough to shape the lining to the drum.

Motorcoach Operating Costs

THE stabilization of motorcoach operation in public transportation is being accomplished rapidly, but one of the contributing factors that still remain to be developed is the standardization of a system of operating-cost determination. Figures released recently by the Motorbus Division of the American Automobile Association indicate that more than 90 per cent of the revenues of motorcoach operating companies is derived from passengers. The figures resulted from a questionnaire sent to 30 companies well distributed throughout the Country, whose operations vary from 10 to 1500 miles of route.

Replies to the questionnaire indicated that the average cost per motorcoach-mile in intercity operations is from 24 to 26 cents; and that the operating costs for budgeting purposes, excepting taxes, can be apportioned in a general way as follows:

	Per Cent
Maintenance	30
Operation	24
Transportation	25
Promotion	3
General Costs	15
Taxes	3

Notwithstanding that considerable work has been done recently by various agencies to develop a standard cost-budgeting system, the methods used vary to such an extent that it is difficult to make direct comparisons of the costs of different operators. This is one of the subjects now being studied by the Society's Operation and Maintenance Committee with the expectation that the Committee will be able to submit a report later in the year.

Traffic-Signal Uniformity

STREET signs, signals, and markings will be the same in all the cities of the United States, and confusion in traffic control will be wiped out, if recommendations in a report soon to be issued by the American Engineering Council are carried out, according to an announcement by the President of the Council, A. W. Berresford. Motorists will be assured of standards as a result of a Nation-wide survey, in which conditions in more than 100 cities, with a population in excess of 35,000,000, were exhaustively investigated, states Mr. Berresford, who is a past-president of the American Institute of Electrical Engineers, one of the constituent bodies of the Council.

Recognizing the wide variation both in types of signs, signals and markings and in their meaning, Mr. Berresford says, the Council, working in cooperation with the Hoover Conference on Street and Highway Safety, aims to eliminate the maze of colors, shapes, and meanings that have been attached to every conceivable accessory for the regulation of traffic. The State of New Jersey has written part of these recommendations into a uniform State law now before the legislature, which, it is expected, will be enacted during the present session.

When driving from city to city we find red, yellow, green, white, blue and other colored signs in every conceivable shade used in traffic control, says Mr. Berresford. The shapes of the signs are as numerous as the colors, and the messages on them are of even greater variety and intent. Pavement markings are less numerous in color, word arrangement and location, but they are nevertheless widely diversified in various cities. The American Engineering Council has aimed to remedy all these bad conditions by recommending a comparatively few standards which, it is intended, shall be of great assistance to motorists, to municipal officials and to the manufacturers of the various products.

Traffic Strangulation Relief

TRAFFIC-CONGESTION problems were analyzed by Mervyn O'Gorman in a paper he presented at the World Motor Transport Congress held in London, England, in 1927. Concerning the remedies for highway congestion, he said, in part, that matter in the wrong place is dirt, but when moved to the requisite place is wealth. Road traffic today, as in the past, is concerned with changing the place of matter mainly with this wealth-producing objective; in doing so it employs labor and capital, but it also takes time. The quicker it goes, the less time it takes, and, for any given amount of transport equipment, the more wealth it produces per day and the less it congests the roads.

Alternatively, we could get the larger amount of transportation per day at the slower speed by using more equipment, up to a certain point. Too much equipment, that is, traffic units, on a road actually causes strangulation of flow and diminishes the total amount conveyed; this increases the capital unproductively locked up in transport equipment, in goods on the way, and in road value. No experiment has been made in any country to determine at what traffic-density strangulation occurs, and consequently no legislature has yet enforced the economical means for preventing it and retaining the maximum flow. Increasing the tonnage of the traffic unit is a palliative limited by axle loads—until we further develop the caterpillar—and leaves us still in need of regulations to secure the maximum safe flow, even of these improved units.

To increase the speed safely up to the road capacity has no economic drawbacks. To limit the speed, makes for congestions which are wasteful.

Production Engineering

Testing Piston-Rings

Special Gages for Determining Accuracy of Form and Tension in the Cylinder

PROBABLY more piston-ring testing is being done now than ever before. Increased engine-speed and higher compression add to the duty imposed on the rings. It is therefore necessary to compare to a very fine degree the dimensions and physical characteristics of piston-rings.

The two major items of piston-ring performance in which engineers are most interested are compression seal and oil control. To secure these effects, a number of physical characteristics must be held within narrow limits. Hardness of the iron, which affects both resiliency and machinability, is tested in a standard Rockwell instrument; width of the ring can be measured by conventional devices, such as micrometers or amplifying gages; and the diameter can be checked by a simple ring-gage. For some other characteristics, special methods of measuring and testing have been devised.

Flatness.—It is extremely essential for the edges of a piston-ring to be absolutely flat. These surfaces are tested by the device shown in Fig. 1, called a radiant gage. This consists of two bell-shaped test plates, between which the ring is placed. In the enclosure formed by this assembly a small electric lamp is placed, and any irregularity in the edge surfaces can be detected readily by corresponding light streaks between the ring and the test plate.

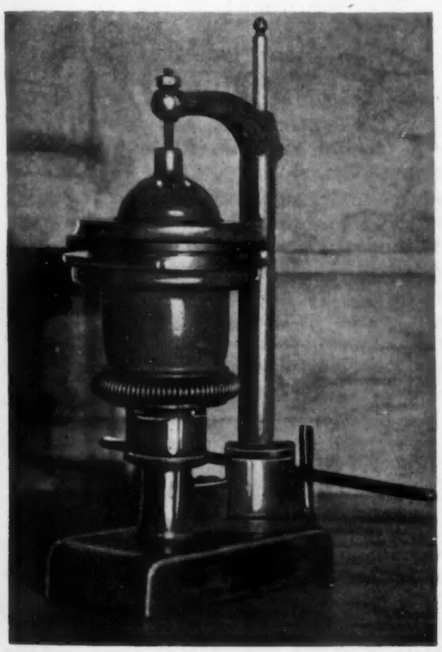

FIG. 1—RADIANT GAGE FOR PISTON-RINGS

An Electric Lamp Shows Light between the Ring and Test Plates if the Faces of the Ring Are Not True

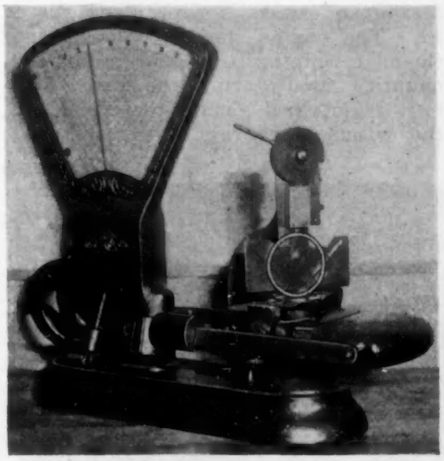

FIG. 2—WEIGHING THE TENSION OF A PISTON-RING

A Fixture Attached to a Scale Platform Holds the Ring and Presses It Together Enough To Close the Gap. The Scale Weighs the Pressure Required

Tension.—The generally accepted method of weighing tension is not a precision method, but has served its purpose so far and is almost universally used. Fig. 2 shows this measurement being made by inserting the ring between two points located at opposite ends of a diameter of the ring at 90 deg. from its joint opening. One of the points is mounted on a scale platform and the other is moved toward it by a cam until the ends of the ring are barely brought together. The weight then recorded on the scale is called the tension.

Cylinder Contact.—Probably the most important test to be made is for face contact between the ring and the cylinder-wall. On account of its frail structure, it is difficult to hold the piston-ring by the edges and machine its face so accurately that the entire face area will contact with the cylinder-wall. For testing this face an accurate ring-gage is mounted on the front of a light-tight box which encloses a powerful electric lamp. A disk slightly larger than the inner diameter of the ring is mounted on a lever so that when the ring is inserted in the gage the disk can be brought into contact with the back of the ring by another lever on the outside of the box. As the disk prevents any light from passing through the center of the ring, it is possible to detect light streaks between the face of the ring and the gage at any point where the ring does not make proper contact. A gage of this sort is shown in Fig. 3.

Circularity.—It has been observed many times that the face of a ring will show 100 per cent contact with the cylinder-wall, yet the radial pressure exerted by the ring against the cylinder may not be uniform throughout its circumference. Radial wall-pressure and its determination have been the subject of much theorizing and discussion.

The only method that has been reduced to practice is to confine the ring to its working circumference in a flexible band which will allow the ring to conform, as nearly as possible, to its inherent shape. A circularity gage using this principle is shown in Fig. 4. This gage consists of a flexible steel tape, *a*, so arranged that it can be drawn in a loop about the ring. By means of a lever, *b*, sufficient pull can be applied to the tape to contract the

FIG. 3—CYLINDER-CONTACT GAGE

A Powerful Electric Lamp behind the Ring under Test Shows Any Imperfection in Fit between the Ring and the Gage

ring to its working diameter. Two dial indicators, *cc*, are mounted at points opposite two pins, *dd*, against which the ring is drawn. The diameters, as measured by these indicators and compared with the diameter of the cylinder, show how near the ring is to true circularity.

It is certain that there must be a definite relation between the shape of the ring when it is bound in a flexible band and the radial wall-pressure at the various points in the circumference. The exact nature of this relationship is, so far, not known, so this is used only as a comparative method of measurement.

Test Method for Gas Leakage

Co-important with the measurement of piston-rings is the practical testing to determine their performance in actual service. Many schemes have been employed for such testing. Road runs in which the car is driven at constant speed, as nearly as possible, is a fair method of comparing the quantity of oil consumed per unit of time or distance. Such comparisons are practical, but are not accurate on account of the ever-changing road and traffic conditions. Also, it is possible to secure data only as to oil consumption by such means; and it now is recognized generally that compression blow-by, or gas leakage, is of equal or greater importance. Accordingly, it is necessary to provide a means to measure such leakage.

It is well-known that blow-by is most destructive to the life of pistons, rings and cylinders. There probably is not an engineer in the industry who has not observed the high temperature that will be caused by a leak from the combustion chamber. A leaky priming-cup or spark-plug will be literally burned up during a few minutes' operation in hard service. This same condition exists between the piston and the cylinder-wall. Nothing but the piston-rings and the lubricant prevent rapid deterioration of these vital parts.

A relationship exists between piston speed and blow-by; as the piston speed increases, the leakage also increases. Similarly, as the power demanded of the engine is greater, leakage also is greater. A knowledge of the rate of change of these conditions is vital to the further development of pistons and rings, and it is therefore necessary to record such measurements.

A dynamometer of a type in which the load and speed can be varied independently of each other is the most convenient brake for piston-ring tests. The crankcase of the engine used in the test must be sealed to prevent leakage, and the breather, or any other convenient outlet from the crankcase, is connected to a very accurate gas meter by which all of the blow-by gas is measured. The temperature of the water both entering and leaving the engine, and of the oil in the oil pan, is held constant, and all the temperatures are indicated by long-distance thermometers.

Procedure of the Test

To make possible a picture of ring performance, a series of separate tests at different speeds is made. It has been found advantageous to begin with an engine speed corresponding to a car speed of 20 m.p.h. A normal quantity of oil is weighed into the engine at the beginning of the run and a constant speed is maintained for 2 hr. The engine then is stopped and the oil remaining is weighed to find the quantity used during the run. The load maintained should correspond to the estimated average power required

FIG. 4—PISTON-RING CIRCULARITY GAGE

Tape *a* Contracts the Ring When Lever *b* Is Pulled. Micrometer Gages *cc* Placed Opposite the Small Pins *dd* Measure the Diameter of the Ring

to drive the car under normal conditions. To record the rate of blow-by at wide-open throttle, the throttle is held wide open for a few moments at some time during the test and the load is adjusted so that the speed will remain constant. The rate of blow-by under road-load conditions is also recorded for the run.

At the completion of a single run the data available are: total oil consumption for 2 hr., blow-by under road load, blow-by under wide-open throttle, fuel consumption, maximum horsepower, and the temperatures of water admitted to and discharged from the engine and of the oil in the oil-pan.

The average mileage per gallon is computed from the oil consumed during the test, and this value locates the first point on the oil-cumsumption curve. Likewise, the rate of leakage at wide-open throttle locates the first point on the blow-by curve. Complete 2-hr. runs are made at speeds from 20 to 60 m.p.h. with increments of 5 m.p.h. To reduce the chance of errors due to inaccuracies and occasional freak results, two complete series of tests are run and all curves are computed from the averages of runs in the two series. —From a paper by R. R. Teetor delivered at the April meeting of the Indiana Section.

Foremen's Conferences

TRAINING in industry is simply the encouragement of right habits of hand and mind until they become a part of the individual's nature.

Mechanical processes have come so rapidly that the question arises: Have we kept pace in the development of the human element? Is the new workman still put on the job to learn it the best way he can? Has the job ever been analyzed to find out what instructional units are involved? Who is held responsible for training the workmen? The answer is always the same; it is the foreman.

The industrial foreman is a composite man. He must be a teacher, salesman, leader, organizer, business man and craftsman. If he is to function efficiently in all of these capacities, he must understand the principles involved and acquire technique. Foreman conferences are meeting with more favor each year as an agency for giving the foreman a new perspective.—R. D. Bundy, in *Trade Winds*, an organ of the Union Trust Co.

Automatic Frame Manufacture

EVERY production man will be interested in John P. Kelley's illustrated description of the automatic frame-making plant of the A. O. Smith Corporation on p. 565 of this issue. It may suggest ideas that can be applied to work of an entirely different nature. The amount of direct labor is not stated by Mr. Kelley, but one visitor reported that only 30 men were working in one shift at the plant, which turns out 7000 frames per day.

Tire Production Paper

A PAPER by B. J. Lemon, printed on p. 508 of this issue of THE JOURNAL, tells of new developments in the manufacture of tires. Methods of producing and handling the raw rubber and the latest way of making cord-tire fabric without cross threads are described. Improvements in methods of fabricating the tire itself and in the powerplant and transportation systems of the factory are treated.

Standardization Activities

Tire Simplification Session

Joint Meeting Approves 17 Sizes and a New Method of Marking

A JOINT meeting of the S.A.E. Special Advisory Committee, and the Tire and Rim Division of the S.A.E. Standards Committee, with representatives of the Tire and Rim Association and the Rubber Association of America, was held March 26 in Detroit to prepare a final table of tire sizes and a method of marking the sizes.

A new table of 17 tire sizes, based on the original S.A.E. and Rubber Association proposals, was submitted by General Manager Viles, of the Rubber Association, for consideration. This table contained two sizes in addition to those in the original table; namely, 5.50 in. on 18-in. rim, and 6.75 in. on 18-in. rim. After consideration and discussion it was voted to eliminate the 5.50 on 18-in. rim size and include the 6.75 on 18-in. rim size. It was further voted to change the designation of tires now known as 6.75 cross-section to 7.00, as the actual section of this size is approximately 6.90 on a 5-in. rim.

It was voted also that tires should hereafter be marked with the cross-section size followed by the diameter of the rim on which the tire is to be used, and that in addition the marking should include, in smaller characters, underneath the foregoing designation, the word "Replaces ———," the blank to be filled in with the existing name size which the new marking replaces. This decision was reached after a discussion of the commercial problem involved in case the actual outside diameter of the tire should be used in the marking of tires and the confusion which would arise from such a change. The new marking takes into consideration only the cross-section and the rim diameter, which are the two main factors involved. The reference to the size replaced is made so as to identify tires of the new marking with those of the old marking for convenience and certainty in servicing.

TABLE OF APPROVED SIZES

The accompanying table embodying these changes and the method of marking was approved by the meeting and recommended to the National Automobile Chamber of Commerce for its early action. This table was voted on also by the members of the Tire and Rim Division of the S. A. E. Standards Committee for submission to the Standards Committee as an S.A.E. Standard on Tires and Rims to replace the present S.A.E. Recommended Practice on Rims for Low-Pressure Tires.

The board of directors of the Tire and Rim Association, who were present with the president of the Association, approved the table of sizes and the method of marking.

Those in attendance at the Detroit meeting were:

W. A. Johnson, Hupp Motor Car Co., Detroit.
G. E. Parker, Cadillac Motor Car Co., Detroit.
H. M. Taylor, Firestone Tire & Rubber Co., Detroit.
K. L. Herrmann, Studebaker Corporation of America, South Bend, Ind.
E. S. Marks, Franklin Motor Car Co., Syracuse, N. Y.
C. P. Thomas, Reo Motor Car Co., Lansing, Mich.
E. A. Hecht, Columbia Tire & Rubber Co., Mansfield, Ohio.
H. R. Platt, Columbia Tire & Rubber Co., Mansfield, Ohio.
A. J. Slatten, Dunlop Tire Co., Buffalo.
V. L. Smithers, Smithers, Inc., Akron, Ohio.
W. T. Fishleigh, Ford Motor Co., Detroit.
J. E. Hale, Firestone Tire & Rubber Co., Akron, Ohio.
J. G. Swain, Firestone Tire & Rubber Co., Akron, Ohio.
B. F. Wright, Chrysler Corporation, Detroit.
H. Morgan, Buick Motor Car Co., Flint, Mich.
C. S. Ash, Wire Wheel Corporation of America, Detroit.
C. S. Holden, Cleveland Welding Co., Cleveland.
E. E. Dearth, Fisk Rubber Co., Springfield, Mass.
E. Botts, United States Rubber Co., Detroit.
C. R. Stewart, Firestone Tire & Rubber Co., Akron, Ohio.
C. L. Wenzel, Budd Wheel Co., Detroit.
C. F. Ofensend, Miller Rubber Co., Akron, Ohio.
R. D. Abbott, Miller Rubber Co., Akron, Ohio.
B. Darrow, Goodyear Tire & Rubber Co., Akron, Ohio.
J. C. Tuttle, Goodyear Tire & Rubber Co., Akron, Ohio.
A. L. Viles, Rubber Association of America, New York City.
J. H. Hunt, Chevrolet Motor Co., Detroit.
B. J. Lemon, United States Rubber Co., Detroit.
L. Thoms, Graham-Paige, Detroit.
A. A. Shelton, India Tire & Rubber Co., Akron, Ohio.
M. B. Minch, Jaxon Steel Co., Jackson, Mich.
N. A. Thomson, Hayes Wheels & Forgings, Ltd., Chatham, Ontario.
A. G. Geistert, Chevrolet Motor Co., Detroit.
C. C. Carlton, Motor Wheel Corporation, Lansing, Mich.
W. R. Griswold, Packard Motor Car Co., Detroit.

TIRE AND RIM STANDARD

Rim Diameter, In.	Tire Cross-Section							
	4.50	4.75	5.00	5.25	5.50	6.00	6.50	7.00
18				5.25–18 Replaces 28x5.25		6.00–18 Replaces 30x6.00	6.50–18 Replaces 30x6.20	7.00–18 Replaces 30x6.75
19		4.75–19 Replaces 28x4.75	5.00–19 Replaces 29x5.00	5.25–19 Replaces 29x5.25	5.50–19 Replaces 29x5.50	6.00–19 Replaces 31x6.00	6.50–19 Replaces 31x6.20	
20		4.75–20 Replaces 29x4.75	5.00–20 Replaces 30x5.00		5.50–20 Replaces 30x5.50	6.00–20 Replaces 32x6.00	6.50–20 Replaces 32x6.20	7.00–20 Replaces 32x6.75
21	4.50–21 Replaces 30x4.50							
Rim-Section Width[1], In.	2.75 Flat Base or Drop Center	4	4	4	4	4½	4½	5
Maximum Tire Width on Rim, In.	4.75	4.85	5.15	5.35	5.60	5.95	6.40	6.90

[1]Rim widths given are nominal except the 2.75-in. size, which dimension is the actual width between flanges.

Method of Marking

Tires shall be marked with the tire cross-section followed by the rim diameter on which the tire shall be used, under which designation shall be placed in smaller type the word "Replaces," followed by the former name-size of the tire.

Alfred Reeves, National Automobile Chamber of Commerce, New York City.

Since the meeting in Detroit, directors of the National Automobile Chamber of Commerce, at their meeting on April 5 in New York City, approved the general idea of tire simplification and have issued to members of their organization a bulletin in which they recommend the use of this table of sizes.

With reference to the method of marking, the Rubber Association of America, subsequent to the Tire Simplification Session, suggested omission of the word "replaces" on future tire-marking, although this expression was approved at the joint meeting. This one point will be referred back to the Tire and Rim Division of the Society for recommendation as to the attitude to be taken by the Society regarding the suggested omission.

Plate-Glass Specifications Revised

THE Passenger-Car Division, at its meeting on April 20, took under consideration the revision of the present specifications on Plate Glass, p. 325 of the 1928 edition of the S. A. E. HANDBOOK. These specifications have been criticized because of the thickness tolerances which, it was brought out, were not in accord with the general requirements of automobile manufacturers.

On the basis of information received from several of the glass manufacturers, the Division has revised the thickness tolerances and omitted the reference to the sizes contained in the first sentence of the present specification.

The revised Recommended Practice, which will be submitted to the Standards Committee for approval, is as follows:

PLATE GLASS

S.A.E. Recommended Practice

The glass producer should be furnished with a templet of the finished glass.

Only polished plate glass shall be used in windshields and front-quarter door windows.

Polished plate glass for windshields and passenger-car windows shall be of two grades: "Selected Glazing" and "Glazing."

"Selected Glazing" plate glass shall contain practically no visible imperfections under specified conditions of inspection. Very fine scattered seeds are permissible.

"Glazing" plate glass shall contain no other visible imperfections than a few scattered seeds and occasional faint strings or faint short finish-marks.

The thickness of plate glass shall be 7/32 in., with tolerances of plus and minus 1/16 in. with variations in individual plates of not more than 1/64 in.

The following definitions of the terms used in the above specifications are taken from the report of the committee on standards of plate glass organized by the Bureau of Standards:

Seeds.—Minute bubbles smaller than 0.015 in. diameter. These are visible only on close inspection, usually appearing as small specks, and are an inherent defect in the best quality of plate glass.

Strings.—Light, wavy, transparent lines on the surface, appearing as though a thread of glass had been partially incorporated into the sheet.

Short Finish.—Poor polish is lack of smoothness, an improperly finished surface which has the appearance of being slightly pitted and wavy when the surface is viewed by reflected light. These indentations, which are slight, have a polished surface rather than a ground surface, but the general effect is a slight dulling of the surface. Poor polish is usually caused by improper grinding. Spots on the surface where the fine grinding has not proceeded far enough to produce a smooth surface before polishing will not polish smooth.

SIZE STANDARDIZATION INFEASIBLE

Acting on the suggestion of a manufacturer of glass for replacement that some standardization should be accomplished on window and door-glass sizes, it was the Division's opinion that any such standardization would hamper body design. The requirements of body manufacturers are constantly changing so far as sizes of glass are concerned, and it was not thought feasible to undertake such work. Therefore this phase of the subject was dropped from further consideration.

Passenger-Car Division Meeting

THE Passenger-Car Division of the S.A.E. Standards Committee held a meeting on April 20 in the General Motors Building, Detroit, to consider the various subjects on which reports had been submitted by the several Subdivisions.

The reports on body-parts nomenclature, steering-wheel tests and plate glass are printed elsewhere in these columns. In considering the subject of door handles with reference to the direction of motion of remote-control handles, it was decided that, while the proposal that all such handles should operate upward was advisable from a consideration of safety, no such recommendation by the Standards Committee would influence the situation, as it is more a function for safety codes to control this feature than to attempt it by standards.

Remote-control handles operating upward have not been satisfactory in doors hung on the rear, as the upward pull to unlatch the lock tends to close the door rather than to assist in its opening. Because of this and the fact that so many varieties of door latches are required by constantly changing body designs, it was decided that no action should be taken.

As a result of the replies received to a questionnaire on the usage of the present specification on car-frame numbers, p. 321 of the 1928 edition of the S.A.E. HANDBOOK, it was found that frame construction prevents the use of a standard location for such a number and that the specification, as now constituted, is not used nor can it be revised so as to be of any value. It was therefore voted that this specification be recommended to the Standards Committee for cancellation.

The present car-performance test specifications, 507 of the 1928 edition of the S.A.E. HANDBOOK, on which a survey had likewise been conducted, was discussed. It was the consensus of views that differences of engineering opinion and differences in equipment available for making car-performance tests make it impracticable to use standard methods of procedure. However, it was felt that some forms for recording the results of such tests might be developed along the same lines as the engine-testing forms. As a result of the discussion it was voted to recommend that the present S.A.E. Specification on Car-Performance Tests be cancelled and a Subdivision appointed by the Division Chairman to investigate the possibility of developing the standard forms referred to.

In view of the wide variance in door design and construction, it was not deemed feasible to continue the proposed work on the door lock standards until more information is available and some suitable condition has been reached in design. It was suggested, however, that door-lock bolt dimensions might be standardized at a future date, and the Division voted to drop this subject for the time being, to take it up again when there is more demand and interest in this subject.

A progress report on the revision of the present leaf-spring specifications was presented by W. H. Wallace, of the Eaton Spring Coporation, chairman of the Leaf Spring Subdivision. This Subdivision will meet again on May 8 in Detroit and submit a final report to the Division on May 9 at a short meeting to be called specifically to consider this subject.

It was decided to have a Subdivision appointed to carry on the investigation of specifications for window-glass channel sections, the need for which was recently pointed out by the Briggs & Stratton Corporation.

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So that the present body and top nomenclature, pp. 499 to 505 inclusive of the 1928 edition of the S.A.E. HANDBOOK, may be brought uptodate to include the newer body types, it was voted to have a Subdivision appointed to study this matter, using data now being collected by the Standards Department from various automobile and body builders.

Aeronautic Standardization Session

Aircraft and Aircraft Parts and Engine Manufacturers Present Their Views

ARTHUR L. NUTT, VICE-CHAIRMAN OF THE AERONAUTIC DIVISION

APPROXIMATELY 150 representatives of aircraft and aircraft parts and engine manufacturers attended a meeting sponsored by the Aeronautic Division of the S.A.E. Standards Committee on April 18 at the Book-Cadillac Hotel, Detroit, during the All-American Aircraft Show. This meeting was called to provide an opportunity for the commercial aircraft industry to present its views on standardization.

While the Aeronautic Division has for the last 18 months been working through its various Subdivisions on numerous subjects, it was felt that an open discussion of the needs of the commercial airplane and parts builders could be more adequately brought before the Division through the medium of a general standards session. At the same time it was desired that comments on and criticisms of the several reports of the Subdivisions be secured before the reports were submitted to the Division for approval at a meeting later the same day.

Edward P. Warner, chairman of the Aeronautic Division of the Standards Committee, who presided, opened the meeting with an outline of the Society's past efforts in Aeronautic Standardization and an explanation of his conception of the method of procedure and the results to be obtained by concentrated effort on standardization for the commercial industry.

The discussion centered particularly around such subjects as the proposed specifications on aircraft storage-batteries, airplane tires and rims, tail-skid shoe mountings, a revision of the present specifications on tachometer drives, and the Army-Navy Standards for eye-bolts, turnbuckles, rigid terminals, and other small fittings, which specifications were proposed for adoption by the Society as standards for the commercial industry.

Among the interesting subjects suggested for future work by the Aeronautic Division were aeronautic ignition cable, mufflers and muffler attachments, engine shielding, and magneto mounting flanges.

The great interest evinced in this work was exemplified by the attendance at the Aeronautic Division Meeting held in the evening of the same day, with about 30 present. An account of the action taken at this meeting will be found elsewhere in this section. So that the work of the Standards Committee may be of maximum value, it is planned to hold similar sessions for further discussion at future aeronautic meetings of the Society and to invite the entire aeronautic industry to be represented.

Aeronautic Division Meeting

THE Aeronautic Division of the S.A.E. Standards Committee held a meeting at 8 p.m., April 18, in Detroit, to act on the several reports submitted by the Subdivisions. The comments and suggestions received at the Standards Session, held in the afternoon and attended by representatives of the airplane, engine and parts manufacturers, were discussed and taken into consideration in connection with each of the subjects acted on.

The following AN Standards were approved for submission to the Standards Committee at the Summer Meeting as S.A.E. Specifications for Commercial Aircraft: eye-bolts, pulleys, shackles, rigid terminals, turnbuckles, and flat washers. The present S.A.E. Specifications on Airplane Bolts and Nuts were revised to be in accord with the latest Army and Navy Specifications for these items.

EDWARD P. WARNER, CHAIRMAN OF THE AERONAUTIC DIVISION

Considerable discussion ensued relative to including material specifications and, following the recommendations of the AN Subdivision, it was decided to include physical properties in all S.A.E. Standards based on AN Specifications, providing also for the marking of the part in some distinctive way to indicate that it is made to give the physical properties required. Any part not so marked is to be understood to be manufactured of low-strength steel. At present an X indicates that fittings are made to AN Material Requirements.

Specifications were approved for submission to the Standards Committee on aircraft storage-batteries providing three capacities and sizes; tail-skid shoe mountings; propeller hubs; gasoline-pump mountings; engine-starter mountings, and generator mountings.

Further work will be undertaken by the Subdivision on Engine Mountings and Propeller Hubs, particularly with reference to the thread specifications for engine-shaft ends. It was voted to disband the AN Subdivision and to have the chairman appoint a Subdivision on Wheels, Tires and Axles, and another Subdivision on Fittings and Small Hardware.

The present Subdivision on Tail-Skid Shoe Mountings will be expanded and renamed and the scope of its work widened. A subdivision will also be organized to study further the generator and starting-motor situation, par-

ticularly with reference to the possibility of including in the mounting specifications some additional dimensions for over-all length and diameter of such equipment. It was suggested also that some future development is looked for in 6-volt equipment, the mounting of which must be taken into consideration.

Full details on all of the specifications approved will be printed in the Standards Committee Division Reports in the June issue of THE JOURNAL.

Cable-Terminal Proposal

THE Subdivision on Cable Terminals has submitted the following report covering changes in the present Cable Terminal Specifications and including a recommendation for a new standard on flexible-conduit ferrules. It is recommended that:

(1) Any effort to standardize junction boxes be dropped.

(2) Cable terminals, as shown on p. 85 of the September, 1927, issue of the S. A. E. HANDBOOK, be revised as shown on the blueprint enclosed with these minutes.

(3) Side type of cable terminals, as shown on p. 86 of the September, 1927, issue of the S. A. E. HANDBOOK, be revised as shown on blueprint enclosed with these minutes.

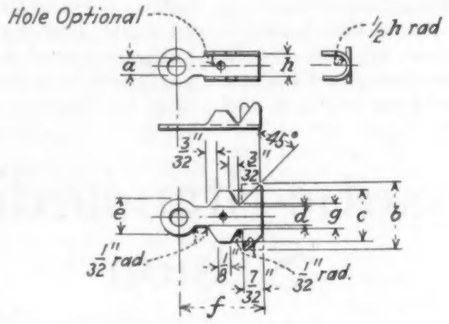
(4) The roll type of cable terminals, as shown on p. 87 of the September, 1927, issue of the S. A. E. HANDBOOK, be discontinued.

(5) The tubular type of cable terminals for starting-motors, as shown on p. 88 of the September, 1927, issue of the S. A. E. HANDBOOK, be continued, with the note added "to be used on small production and for service work only." The addition of the open-wing type of cable terminals, as shown on the enclosed blueprint, is recommended. This is to be specified as a preferred design and for quantity production, as it is better for assembly and inspection and will give better soldered joints.

(6) Cable, conduit and tubing clips, as shown on p. 89 of the September, 1927, issue of the S. A. E. HANDBOOK, be revised as per blueprint herewith.

(7) Flexible-conduit ferrules. It was recommended that the proposed S. A. E. Standard, as shown on the blueprint enclosed, be approved for inclusion in the S. A. E. HANDBOOK.

L. O. PARKER,
Chairman, Subdivision on Cable Terminals.



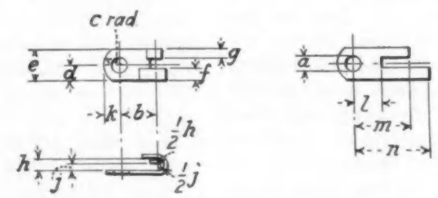
STRAIGHT TYPE CABLE TERMINALS

Terminal No.	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*	Thickness
A 1	0.190 0.195	21/32	1/2	3/16	11/32	13/16	1/4	7/32	1/32
A 2	0.253 0.258	25/32	5/8	1/4	9/16	7/8	7/16	1/4	1/32
A 3	0.320 0.325	25/32	5/8	1/4	5/8	7/8	7/16	1/4	1/32
A 4	0.400 0.406	25/32	5/8	5/16	11/16	7/8	7/16	1/4	0.040

Alternate Construction.—The wings which clamp the cable may be cut square as indicated by dotted lines.

Material.—Soft sheet copper, S.A.E. Specification No. 71 or soft sheet brass S.A.E. Specification No. 70.

Terminals shall be free from burrs, corrosion or any foreign matter. The temper of the terminals shall be sufficiently soft to permit the terminal being assembled with the wings closed and not show any fracture or cracks which would impair the strength of the assembly.

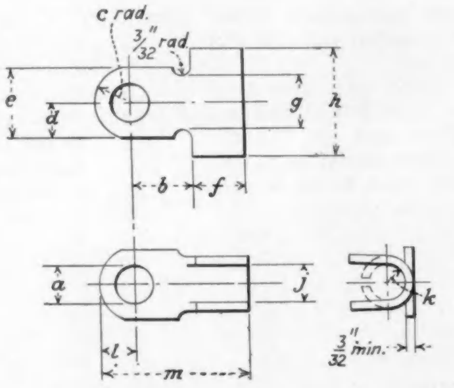


SIDE TYPE CABLE TERMINALS

Terminal No.	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*j*	*k*	*l*	*m*	*n*	Thickness
B 1	0.125 0.128	11/32	3/16	5/32	5/16	1/8	3/32	7/64	1/16	5/32	9/32	9/16	3/4	1/32
B 2	0.190 0.195	9/32	7/32	3/16	3/8	5/32	1/8	5/32	5/64	3/16	1/4	35/64	21/32	1/32
B 3	0.190 0.195	11/32	7/32	3/16	3/8	5/32	1/8	7/32	1/8	3/16	5/16	47/64	15/16	1/32
B 4	0.190 0.195	13/32	7/32	3/16	3/8	5/32	1/8	5/32	5/64	3/16	3/8	43/64	25/32	1/32
B 5	0.253 0.258	9/16	5/16	1/4	1/2	3/16	7/32	9/32	7/32	1/4	1/2	1 3/16	1 5/16	0.040
B 6	0.320 0.325	9/16	1/2	3/8	3/4	5/16	11/32	9/32	7/32	3/8	1/2	1 3/16	1 5/16	0.040
B 7	0.400 0.406	9/16	1/2	3/8	3/4	5/16	11/32	9/32	7/32	3/8	1/2	1 3/16	1 5/16	0.040

Material.—Soft sheet copper, S.A.E. Specification No. 71 or soft sheet brass, S.A.E. Specification No. 70.

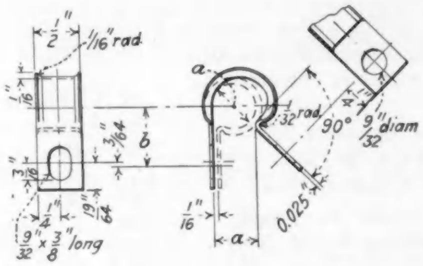
Terminals shall be free from burrs, corrosion or any foreign matter. The temper of the terminals shall be sufficiently soft to permit the terminal being assembled with the wings closed and not show any fracture or cracks which would impair the strength of the assembly.



STRAIGHT TYPE FOR STARTING MOTORS

Terminal No.	Wire Size	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*j*	*k*	*l*	*m*
C	1	13/32	21/32	13/32	3/8	3/4	9/16	19/32	1 3/16	13/32	11/64	3/8	1 19/32

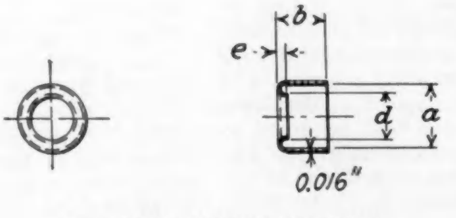
Material.—Soft sheet copper, S.A.E. Specification No. 71 or soft sheet brass, S.A.E. Specification No. 70.



CABLE, CONDUIT AND TUBING CLIPS

a	Diameter	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
b	Length	15/32	1/2	17/32	9/16	19/32	5/8	21/32	11/16	3/4	13/16	7/8

Material.—S.A.E. No. 1010 Steel or equivalent, cold rolled dead soft.
Clips shall be made to full lines, as shown above, and bent to dotted lines when assembling. They must be free from burrs and sharp edges.



FLEXIBLE CONDUIT FERRULES

	Conduit Diameter	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1	1 1/4
a	Inside Diameter	0.285	0.355	0.425	0.485	0.555	0.630	0.760	0.930	1.040	1.175	1.435
b	Length	1/4	1/4	1/4	3/8	3/8	3/8	1/2	1/2	1/2	5/8	5/8
d	Shoulder Diameter	0.188	0.250	0.313	0.375	0.438	0.500	0.625	0.750	0.875	1.000	1.250
e	Shoulder	1/16	1/16	1/16	1/16	1/16	1/16	3/32	3/32	3/32	1/8	1/8

Material.—Soft sheet brass, S.A.E. Specification No. 70 or S.A.E. No. 1010 dead soft sheet steel.
All steel ferrules must be zinc or cadmium plated to withstand salt spray test for 24 hr. without showing rust.

Chain Standards Progress

A REVISION and extension of the present standards for roller and for silent transmission-chains given in the 1928 edition of the S.A.E. HANDBOOK, beginning on p. 44, is being prepared by a Sectional Committee, sponsored by the Society of Automotive Engineers, the American Society of Mechanical Engineers and the American Gear Manufacturers Association, under the procedure of the American Engineering Standards Committee. The purpose is to bring the standards into line with modern practice.

At a meeting of the Subcommittee on Roller Chains in Rochester on April 18, action was taken toward eliminating the present medium and light series of chains and substituting a new medium series of ½, 1, 1¼ and 1½-in. pitch chains that are now being made; modifying the present heavy series, and proposing a new series of extra-heavy roller chains with pitches from ¾ to 2 in. inclusive in ¼-in. increments. A ⅝-in. pitch rollerless-bushing chain was also proposed, to which will be added later a ½-in. pitch size. The standardization of block chains and the layout of patterns for cast sprocket teeth were also considered. With regard to sprockets, the sprocket-tooth form for cut teeth and the design of cutters, as included in the present standards, were approved at a previous meeting of the Subcommittee.

TENTATIVE SILENT-CHAIN PROPOSAL

The Subcommittee on the Silent or Tooth Form of Chain also held a meeting in Rochester on April 19 as the result of a questionnaire that had been sent out, most of the replies to which indicated approval of some program of standardization for this type of chain. In general it was recognized that it would be difficult to standardize the chain itself, but the belief was expressed by many that much could be done in connection particularly with the sprockets. The Subcommittee is faced with a more difficult problem than that of roller chains, because silent-chain standardization involves more complex features of design and operation, such as variations in working angle, the tangency radii and the several methods of guiding silent chains. However, the Subcommittee drafted a tentative proposal including chains with nine pitches ranging from ⅜ to 2½ in.

The recommendation includes the nominal and actual pitches, tangency radii, working angle, outside diameter of the sprocket-wheel with tolerance, the link thickness and the minimum width and depth for the guide groove. Three suggested optional contours of the guide groove and a suggested table of 19 chain widths from ½ to 20 in. inclusive was also prepared. The report of the Subcommittee will not be

published generally until it has been reviewed by the Subcommittee, including the silent-chain manufacturers.

The reports of both Subcommittees, when completed, will be submitted to the entire Sectional Committee for approval and submission to the sponsors and finally to the A.E.S.C. for final adoption. The reports will, of course, also be published and distributed generally before final adoption, to give all manufacturers and users ample opportunity to review and comment upon them prior to their final adoption.

Steering-Wheel Tests Approved

THAT purchasers of steering-wheels may have a suitable method of making tests for comparative purposes, it was suggested that the Standards Committee of the Society undertake the development of a standard test procedure for determining steering-wheel strength. As a result, a Subdivision was appointed to develop such procedure for consideration.

The following report was submitted by F. D. Pease, of the Studebaker Corporation of America, to the Passenger-Car Division at its meeting on April 20, which report was approved for submission to the Standards Committee at the Summer Meeting for adoption as an S.A.E. Recommended Practice:

Proposed Standard Test Procedure for Steering-Wheels

Static-Load Tests.—Each wheel should be placed in a Tinius Olsen or other suitable testing machine and the rim supported midway between spider arms on two steel blocks approximately 3 in. square diametrically opposite each other. The wheel may be placed either in the position as normally seen or upside down, as tests should be made with wheels in each position.

Load is applied uniformly and slowly downward through the hub until an initial failure occurs, which should be noted, and the loading continued until complete failure occurs. As previously mentioned, tests should be conducted with the wheel right side and bottom side up as viewed from the driver's seat.

Impact Tests.—Each wheel should be supported rigidly at the hub by means of a bolt passing through the hub and a steel block clamped rigidly to the bed of a drop-hammer.

Impact is applied by means of a 20-lb. weight working freely in vertical guides. The weight is allowed to drop from a measured height and to fall on the rim midway between spider arms. The shock is cushioned by means of a piece of ⅜-in. pure para sheet rubber 4 x 5 in., which is clamped over the rim at the point of impact.

The distance which the weight is dropped to cause, (*a*) initial failure, (*b*) ultimate failure, and the characteristics of the failure should be noted.

As in the static load tests, wheels should be tested in two positions.

Determination of Moment of Inertia.—The pendulum method for determination of moment of inertia is used.

From Poorman's Applied Mechanics, Article 108, the radius of gyration of a compound pendulum is

$$K = T/2\pi\sqrt{gd}$$

where

T = time of one oscillation in seconds
g = acceleration of gravity
d = distance in feet from axis of rotation to a parallel centroidal axis.

Each wheel should be suspended on a knife edge from the inside of the rim and the time for 100 complete vibrations determined. From this the time T can be determined.

The distance d is measured from the point of suspension on the inside of the rim to the axis of rotation of the wheel. The weight of the wheel is determined in pounds:

Then, $I = I_0 - md^2$ or, since $K = T/2\pi\sqrt{gd}$, and $I = M(K^2 - d^2)$,
$$I = W/g\,[(T/2\pi)^2(gd - d^2)]$$

FRANK D. PEASE,
Subdivision on Steering-Wheel Tests.

Body-Parts Nomenclature

AS a result of the investigation and survey made by the Subdivision on Body-Parts Nomenclature, working under the chairmanship of J. B. Judkins, a report was submitted by the Chairman to the Passenger-Car Division at its meeting on April 20.

This report was approved by the Division for submission to the Standards Committee in June. On a subject of this kind it is difficult to discuss adequately all items involved and the report is published to elicit comment and criticism. If any opposition develops, further consideration will be given to the report by the Subdivision and the Division prior to its submission to the Standards Committee.

Body Frame-Parts Nomenclature

S.A.E. Standard

Part No.	Name
1	Dash post
2	Dash
3	Cowl strainer
4	Cowl bar
5	Roof slat, left
6	Roof bow No. 1
7	Roof slat, center
8	Roof rail, front
9	Roof bow No. 2
10	Roof slat, right
11	Roof bow, No. 3
12	Dome-light block, front
13	Roof bow, No. 4
14	Front-door header
15	Roof bow No. 5
16	Rear-door header
17	Side roof rail, right
18	Side roof rail filler
19	Roof bow No. 6
20	Roof bow No. 7
21	Rear-window frame
22	Rear roof rail
23	Rear corner pillar
24	Rear-window side strainer, right
25	Rear-window side strainer, left
26	Rear belt rail, lower
27	Rear seat strainer, left
28	Rear belt rail, upper
29	Rear back strainer, right
30	Rear-quarter pillar
31	Rear corner belt rail
32	Right rear corner strainer, upper
33	Right rear corner strainer, lower
34	Wheelhouse, rear
35	Rear-quarter strainer, lower
36	Rear-quarter strainer, upper
37	Rear-quarter belt rail
38	Rear cross sill
39	Kick-up sill
40	Wheelhouse, front
41	Rear-door body hinge pillar
42	Rear-door belt rail
43	Rear-door strainer
44	Rear-door hinge pillar
45	Kick-up filler block
46	Rear-door bottom bar
47	Rear-door bottom board
48	Rear door-hinge pillar, lower
49	Rear-door lock pillar
50	Front-door lock pillar
51	Front-door bottom board
52	Front-door bottom bar
53	Front-door strainer
54	Front-door belt rail
55	Front-seat top rail
56	Front-door hinge pillar
57	Front-door body hinge pillar
58	Division side pillar
59	Cowl belt bar
60	Cowl belt-bar filler block
61	Cowl side strainer
62	Main-sill cross bar No. 2
63	Main-sill cross bar No. 1
64	Main sill, right
65	Toe-board bracket
66	Main-sill cross bar No. 3
67	Center body pillar, right
68	Dome-light block, rear
69	Rear-quarter header bar
70	Rear-quarter lining-board
71	Reardoor lock board
72	Front-door lock board
73	Windshield header bar

Detroit Aeronautic Division Meeting

Over 600 Hear Klemin Discuss Guggenheim Award—Visits to Airport, Engine Plant and Aircraft Show

UNQUESTIONABLY the most interesting and important feature of the 2-day meeting of the Detroit Section Aeronautic Division was Alexander Klemin's exposition of the requirements of the Daniel Guggenheim Safe-Aircraft Competition. Professor Klemin also outlined the various possibilities in the light of present-day knowledge that may be used in the design of the winning airplane.

The basis of the competition, for which an award of $100,000 has been established, is given on the next page. Professor Klemin's complete paper, delivered at the session on Tuesday evening, April 17, will appear in an early issue of THE JOURNAL.

Included in the complete program of the meeting were a trip to the Ford Airport on the morning of April 17; a trip to the All-American Aircraft Show in the afternoon; a dinner and technical session in the evening; and, on Wednesday, April 18, a visit to the Packard aircraft engine plant in the morning; an open Standards Committee session in the afternoon, and an Aeronautic Standards Division meeting in the evening. Motorcoaches and passenger-cars were provided for the visiting members in connection with the inspection trips.

At the Ford Airport the S. A. E. members inspected the airplanes on the field, many of which had been flown to Detroit by those connected with the Aircraft Show. They also visited the Stout factory, where they had an opportunity of studying the construction and the manufacturing methods of the Stout all-metal tri-motor airplanes used for sightseeing over Detroit and for the Detroit-Cleveland Airline. More than 100 of the visitors took the opportunity of seeing Detroit from the air, three of the large airplanes being kept in operation for the Society members during their visit.

Following the inspection visit, the members were taken to the Dearborn laboratories for lunch as guests of the Ford Motor Co.

Tuesday afternoon had been left open so that members would have time to visit the Aircraft Show, and the number that availed themselves of the opportunity so offered indicated that the committee in charge of the program had acted wisely in making this arrangement.

DINNER AND TECHNICAL SESSION

More than 600 members and guests were present at the technical session on Tuesday evening, in the ballroom of the Book-Cadillac Hotel, and more than 450 attended the dinner which

Basis for $100,000 Award in Safe-Aircraft Competition

1.—Speed Tests
(a) 2 points for every mile per hour less than 35 m.p.h. at which level controlled flight can be maintained. Maximum number of points obtainable 10
(b) 4 points for every mile per hour less than 38 m.p.h. which is not exceeded in a steady controlled glide during a period of 3 min. Maximum number of points obtainable. 24
(c) Any aircraft which obtains a combined total of at least 24 points under tests (a) and (b) will be eligible to receive points for high speed in excess of 110 m.p.h. as follows: 1 point for every 2 m.p.h. in excess of 110 m.p.h. at which level flight can be maintained. Maximum number of points obtainable 10

2.—Test of Landing Run
2 points for every 3 ft. less than 100 ft. in coming to rest after first touching ground. Maximum number of points obtainable 40

3.—Test of Landing in Confined Space
1 point for every 2 ft. less than 300 ft. from the base of an obstruction 35 ft. high in coming to rest after gliding in over the obstruction. Maximum number of points obtainable 75

4.—Test of Take-Off
1 point for every 15 ft. less than 300 ft. required to take off from standing start. Maximum number of points obtainable 15
1 point for every 10 ft. less than 500 ft. to clear obstruction 35 ft. high from a standing start. Maximum number of points obtainable 26

Total Points 200

preceded the session. The dinner was enlivened by a special entertainment, and a model-airplane competition was held immediately afterward, the interest in the various models being divided equally between their aerodynamic features and their gyrations.

The meeting was convened by W. T. Fishleigh, chairman of the Detroit Section, who, before relinquishing the chair to L. M. Woolson, chairman of the Aeronautic Division, introduced Secretary Coker F. Clarkson. Mr. Clarkson complimented the Detroit Section on the series of excellent meetings that have been conducted this season and the organization of the Aeronautic and Body Divisions. Credit for the success of the Aeronautic Division Meetings was attributed by Captain Woolson to the Division officers; W. C. Naylor, Ivan Driggs, Ralph Upson, W. B. Stout and J. T. Whitaker. Captain Woolson then introduced Hon. Edward P. Warner, assistant secretary of the Navy, who presided as the chairman of the technical session, at which Professor Klemin presented his paper.

PROF. ALEXANDER KLEMIN

L. M. WOOLSON

AIRCRAFT ENGINE-WORK INSPECTED

Wednesday morning, April 18, a party of about 150 members of the Society and visitors at the Show went in motorcoaches provided by the American Car & Foundry Co. and in a number of Packard cars to the plant of the Packard Motor Car Co. escorted by a police detail. On arriving at the plant an interesting talk was given by L. M. Woolson on the several types of Packard aircraft engine, during which many interesting mechanical details of the several types were described. Toward the end of Mr. Woolson's address, motion pictures showed the methods of installing and testing the Packard engine used in the Navy racing airplane flown by Paul Williams. Following this, the assembling of aircraft engines was inspected and dynamometer tests were demonstrated on two of the models. The party then returned to the Book-Cadillac for the afternoon meeting on the discussion of aeronautic standards.

An account of Mr. Woolson's description of the engine is published on page 602 of this issue of THE JOURNAL in the report of the April meeting of the New England Section, at which he presented similar material.

AERONAUTICAL STANDARDS ACTED ON

The open Aeronautic Standards Session on Wednesday afternoon at the hotel was attended by more than 100 aeronautical and parts engineers and presided over by the Hon. Edward P. Warner, chairman of the S. A. E. Aero-

W. C. NAYLOR

nautic Standards Division, which held a regular Division meeting during the evening. Many reports were definitely acted upon and other subjects were scheduled for further study. An account of both of these meetings is given on p. 591.

A Joint Aeronautic Day

BUFFALO Section members participated in a double-session aeronautic meeting on April 17 organized by the Engineering Society of Buffalo and attended also by members of the American Welding Society, the American Institute of Electrical Engineers and the Engineering Institute of Canada.

Inspection visits to the Buffalo Airport, the Curtiss Aeroplane & Motor Corporation and the Consolidated Aircraft Corporation in Buffalo occupied the afternoon. At the evening session C. Roy Keys, vice-president of the Curtiss Company, gave an address on Recent Progress in Aeronautics, dealing mainly with the rapid growth of aircraft production in the last 2 years; and H. C. Ritchie, of the General Electric Co., spoke on Developments in Airport Lighting. Motion pictures made by Baron C. Shiba, of Tokyo, and loaned to the Engineering Society of Buffalo by the aeronautic division of the American Society of Mechanical Engineers, were exhibited. These showed photographs of rapidly moving objects taken at a rate as high as 20,000 exposures a second. As the film was run off, explanations were made by Marsden Ware, of the A.S.M.E. A description of this film is given in the news account of the Detroit Section regular monthly meeting on p. 606.

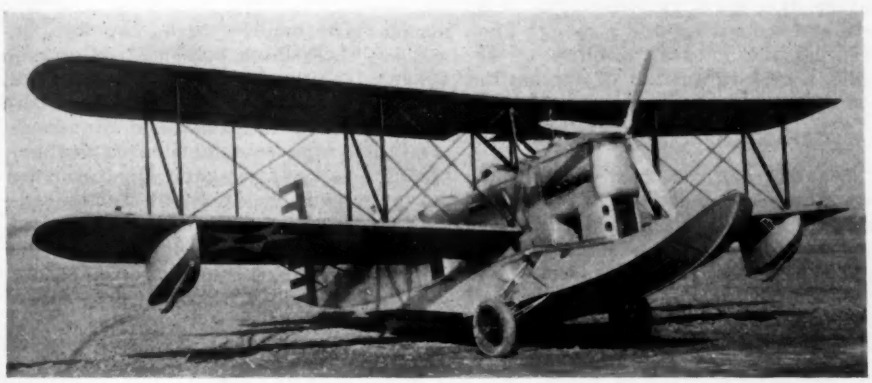
M.I.T. Branch Hears Hottel

HOYT C. HOTTEL, research associate in the department of chemical engineering, Massachusetts Institute of Technology, addressed the M.I.T. Student Branch at its meeting held April 27, his topic being Gasoline and Its Future. Mr. Hottel discussed the various sources of gasolines and gasoline substitutes, as well as the processes employed in their production.

Commercial Aviation Paying

Spirited Talks by Airplane Men at Cleveland Stir the Imagination

"YOU may call the men in aviation visionary, but there is in aviation a basic thing that is destined to make it the greatest transportation industry in the history of the world and the greatest civilizing instrument that has ever been invented."

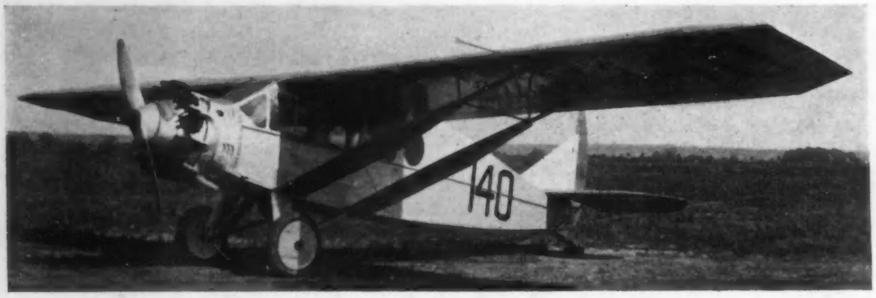


These phrases by "Bill" Stout reflect some of the optimism and spirit of the four speakers at the exceptionally interesting aeronautic meeting of the Cleveland Section on April 9, which was attended by about 200 members and guests. Section Chairman S. L. Bradley convened the meeting at 8:20 p. m. in the Hotel Cleveland. As an entertainment feature, motion pictures of the chassis-assembling contest at the 1927 Summer Meeting were run off, and Chairman Bradley assured the members that the real contest was even funnier than the reel pictures.

Referring to the Section's aeronautic meeting last year, Mr. Bradley recalled the sharp differences of opinion then expressed regarding the future commercial possibilities of the airplane, saying that some speakers contended that the airplane in its then stage of development did not lend itself to use as a passenger-carrying vehicle. A great deal has happened in the supervening 12 months to give the aeronautic industry great impetus, and today hardly any city of consequence is without an airport. Mentioning specifically Cleveland's opportunity to have an airport on the lake front, he said he hoped the city would have such a port within 5 min. distance from the downtown hotels. The chair was then relinquished to E. W. Weaver, who arranged the aeronautic meetings for both years.

Martin Foresees Huge Commercial Market

Taken together, the talks by the four aviation men presented an amazing picture of the quick development of commercial flying in America, and of its present statistical and financial status; contained a commentary on the groundmindedness of our business men; and showed keen regret for the city's indif-



ference which resulted in the decision of Glenn L. Martin to remove his airplane plant from Cleveland to the East.

Mr. Martin, announced as the first regular speaker, said that aviation is becoming a real business and that there is real money behind aircraft for both military and commercial use; but the commercial side is advancing so much faster than the military side that a projection of the curves will easily convince anyone that the commercial market will go away beyond the military market. Regarding the latter, he said that the Navy is spending $45,000,000 apiece for airplane carriers and that the Saratoga and the Lexington are the beginning of the Navy's program for going to sea with aircraft. It hopes to have $250,000,000 invested in carriers and $100,000,000 additional invested in aircraft. The Army will have more aircraft in operation than will the Navy. Next year's appropriation for the Navy for aircraft alone, not including engines and accessories, is $16,000,000, and the Army will get $11,000,000 for aircraft, all to be spent in 12 months beginning next July.

About 50 concerns in the United States, said Mr. Martin, are now producing commercial aircraft, and the time is not far distant when the commercial-aircraft market will reach perhaps $100,000,000 or $200,000,000 yearly.

Cleveland's Transport Companies

Cleveland built the first municipal airport ever constructed in the world, asserted Major John Berry, of the Cleveland airport, the next speaker. He hinted, however, at the possibility of the city losing its airlines unless the people help the men who have pioneered these developments and invested their money in them. We are flying 25,000 miles a day in this Country now, he said, and in two years of commercial aviation he does not know of a structural failure. At the Cleveland airport six concerns are engaged in transporting passengers. The Thompson Aeronautical Co. has airplanes available 24 hr. a day to go anywhere in the United States, and the airplanes operated daily between Cleveland and Detroit by the Stout Air Services have a factor of safety second to none in the world, according to the speaker, and the airline has a performance record since its inception that never has been equaled in commercial aviation in this Country, including the Air Mail.

More details regarding the service of the Thompson Aeronautical Co. were given by Mr. Thompson, of that organization, who spoke next. This service grew out of Mr. Thompson's desire to have quicker transportation for the executives and salesmen of the parent company. After putting one airplane to this use, a decision was reached to provide the same facilities for other Cleveland industries, and although hampered by the natural timidity of the public, a certain amount of success has been achieved.

Safety and Speed of Air Travel

"You are more safe in an airplane than in any automobile ever built," declared W. B. Stout, president of the Stout Air Services, the final speaker. In rapid-fire narrative style interpersed with humorous sallies, Mr. Stout told of many flying trips to illustrate the great economy of time effected by airplane travel. "You do not realize," he said, "that Detroit and Cleveland are now suburbs of each other. The other day Floyd Bennett and Bernt Balchen were over at the Dearborn airport and did not have a car. They had about three-quarters of an hour to go down town for lunch, and it takes about 1½ hr. to do that. So they got into an airplane, flew over to Cleveland, ate next to the airport there, and flew back to our airport in less time than they could go into Detroit and get back. There have been many times when we have flown 50 miles out of our course to land in a field where there was a hot-dog stand. What is 50 miles compared to a hot-dog?"

Mr. Stout also gave an interesting running account of his flight to Mexico City and back with Mrs. Lindbergh, saying that they flew from Mexico City to San Antonio, Texas, a distance of 350 miles, in 4 hr. 45 min., whereas the train time is 43 hr. "You can carry passengers into Mexico City by airplane for less money than the railroad fare, and make money. It is in these out-of-the-way places that the airplane can save a tremendous amount of time. The airplane is going to have a future there and be of the greatest benefit to mankind."

The flying time from Detroit to Mexico City and back was no longer than that of an automobile drive to Chicago and return that he made the week prior to the Cleveland meeting, asserted the speaker, and the flying trip was made with about one-tenth the fatigue and excitement that were experienced in driving the automobile to Chicago.

Business Done by Radio Telephone

What he believes to be the first instance of business transmitted by telephone from an airplane occurred on a trip last year to the City of Washington, where the Bureau of Standards installed a radio telephone in the airplane as an experiment. Up in the air over the capital, Mr. Stout started calling numbers in the city. "We called the Ford branch and the girl at the switchboard, not knowing where we were, asked: 'Do you know where Mr. Mayo is? The factory in Detroit is trying to get him.' We said, 'He is right here.' So we put him on the telephone and she talked with him."

On a trip to Winnipeg, from which place they returned only 2 days before the Cleveland meeting, Bennett and Balchen had gone to the Rainbow Lake region to see how the airplane would act when fitted with skis. Hearing of a gold rush, they loaded 11 men into the craft, together with sleeping bags, two weeks' supplies and fuel for 14 hr., and took off in a temperature of 40 deg. below zero. Their time to the new gold field was 3 hr., Mr. Stout thought, whereas the trip would have taken 15 days "dog time."

"Until airplanes began to appear that had some semblance of commercial value," said the speaker, referring to

the financing of aviation, "we could not go ahead in Detroit. You could not show a Government contract to a Detroit banker and look him in the face. The banks got 'stuck' enough when the war ended and did not want any more; but they have been willing to furnish money for commercial airplane construction, and that is why Detroit is developing as a commercial aviation center.

Making Money in Aviation

"Now we are getting to a point where we can make money in aviation. Three years ago 85 per cent of the airplanes built in this Country were military craft built under Government contract. Last year 28 per cent were military, and within 5 years you will see 2 or 3 per cent military, and they will mostly be built by the Government factories, because the private factories will be too busy filling the orders of the public. With Mr. Ford's going into aviation, business men began to look into it. Then new aviation projects began to spring up in Detroit."

Mr. Stout here told of a number of enterprises into which he had put money and which had paid profits. One of these is an airline in the West that has been operating on a mail contract for two years, flying 1400 miles per day and having applications to carry more passengers than it can accommodate. This line, starting with $298,000 paid-in capital, now has $450,000 in the bank and is earning from $11,000 to $14,000 a month, asserted the speaker, who declared that "almost every air-mail line in the United States is today in black ink. About 10 times as much civilian flying is going on as you suppose. Ninety-five per cent of the flying is done west of the Mississippi River."

"When Glenn Martin moves out of Cleveland the city is going to lose the greatest asset it has ever had in one man, and you are going to realize that within two years," asserted Mr. Stout. "If the people had got behind him and let him build commercial airplanes, which he wants to do, the city would have an airplane industry. There is not an airplane concern in the United States that can build one-fifth the airplanes it could sell next year. We are going to have better engines very shortly, and are going to have better fuels, lighter and stronger structures, and better airports. And when we get through we are going to carry loads as cheaply per mile as in any other way. Today an airplane costs a lot of money, because we are building one a week. That is not production; nor is one a day or 50 a day production. That city is going to be an aviation center whose bankers and financiers have the vision to do their part; and they cannot get that vision while sitting behind a desk."

Meeting at University

ENGINEERS and student engineers to the number of about 255 mingled at the University of California on April 12, when the Northern California Section members were guests of the Associated Electrical and Mechanical Engineers of the University. During dinner, which was served in Stephens Union Hall, there was vocal and banjo music by campus talent. A. G. Montin, president of the association, welcomed the visiting engineers and then introduced A. H. Hoffmann, professor in the Department of Agricultural Engineering at Davis, Cal., to act as chairman of the meeting.

W. S. Penfield, chairman of the Section, W. W. MacDonald, E. C. Wood and Edward Meybem, East Bay vice-chairman, made brief remarks, and Fred L. Sargent, chairman of the Meetings Committee of the Section, announced that the next Section meeting will be held May 10, at the Engineers' Club in San Francisco, on the subject of commercial bodies. Weight saving is to be given particular consideration.

What the Speakers Discussed

Superchargers were treated in a paper by J. Milton Davies, research engineer of the Caterpillar Tractor Co., who included history and elementary considerations along with a large amount of information about applications of superchargers to airplanes, racing cars, passenger cars, tractors and Diesel engines.

Dean Baldwin M. Woods, professor of aerodynamics at the University, followed with a paper on The Problem of Maximum Range in Airplane Design. He gave interesting data on what has been and can be accomplished in the way of weight saving in the powerplant, and on propeller efficiency and the lift-drag ratio. He also outlined, with the aid of curves, the methods for finding the most economical speed and altitude for long-distance flights under various conditions.

Radiator fans have been subjected to extensive laboratory tests by Carl Voight, who gave his results in the next paper. The outlines of eight automobile fans were shown in diagrams, usually with the camber of the blades; and their performance as to volume of air and horsepower required was shown in a series of charts. Mr. Voight concluded that fans should be as large as the radiator will permit and should be designed for relatively low speed, and that the use of a good shroud greatly increases the volume of air with no increase in power consumption. Without a fan, air has been observed to filter through the radiator at about half the speed of the car.

Discussion centered in an account by Brooks Walter of the application of a supercharger to a Caterpillar tractor for logging work at a 5000-ft. altitude. The technical meeting was followed by inspection of the mechanical, electrical and hydraulic laboratories of the University.

Tooling for Car Manufacture

ON April 3, members of the Buffalo Section to the number of about 70 met to discuss production problems. J. C. Talcott, chief engineer of the Pierce-Arrow Motor Car Co., acted as chairman, and Charles B. Ekdahl, chief tool engineer of the same company, read a paper on Some Phases of Automotive Production.

It sometimes seems to Mr. Ekdahl that the automobile engineer spends all his time in searching out the design of car that will be most difficult to manufacture. At least in the early days the chief concern of the engineer, he said, was to design a car that would run; it is quite another thing to design a car so that it can be built economically.

Growth of production needs has outstripped the supply of skilled workers. For that reason, the brains and skill of high-class mechanics have been used to furnish equipment whereby an ordinary workman can turn out high-grade work. It is not that the skilled machinist of a generation ago has become extinct; he has become the toolmaker of today, and the more ingenious of the toolmakers have become tool engineers and production engineers whose job it is to convert the ideals of automotive engineers into practicabilities.

New Design Starts Tooling Activity

When a new design is approved for production, a struggle is begun by the production and purchasing divisions,

the machine-tool operators and the machine-tool manufacturers. The most important of the activities of this period, according to the speaker, is the designing of special tools. In this work the tool designer must observe strict limitations of cost and time. When special machines are needed it often is necessary to use modifications of existing machines, and the production engineer must always work without the opportunity to experiment that is offered to the designing automotive engineer.

In the discussion, George D. Miller, plant superintendent of the Curtiss Aeroplane & Motor Co., explained the difference between the manufacturing requirements for automobile and for aeronautic work. The latter is more like the work of a big jobbing shop.

In reply to a question, both Mr. Ekdahl and Hans Buerk, a Buffalo tool manufacturer, said that it would not be economical for large manufacturers to employ the number of toolmakers and furnish the equipment required to produce so many tools as they need in a short space of time. The tools usually are designed by the manufacturer's engineers but are made by toolmaking specialists. This applies to quantity manufacturers both inside and outside the automotive industry, including also the various makers of cameras and typewriters.

Aluminum for Automotive Use

Rapid Technical Development of Aluminum Outlined and Products Described

As much as half of the entire production of aluminum has at times been consumed by the automotive industry and it is natural that much of the development has been done on aluminum products suited to that industry, said R. S. Archer, of the research bureau of the Aluminum Co. of America, in presenting his paper at the meeting of the Chicago Section, held April 10 at the headquarters of the Western Society of Engineers. Continuing, he reviewed briefly the history of aluminum, included valuable information regarding the composition and characteristics of the various aluminum alloys, and gave illustrations and explanations of the various aluminum products that are used in automotive work.

Chairman F. G. Whittington, preceding the delivery of the paper, made announcement of the various Section meetings of the Society that were to be held throughout the Country during April, suggesting that those members who might be en route on business during the month make an effort to attend these meetings. He also announced the arrangements made for transportation to the Semi-Annual Meeting to be held in Quebec, and urged the members and guests present to attend this meeting.

Aluminum Products

Corresponding progress in fabricating processes to that of the progress which has been made in the development of aluminum alloys and their heat-treatment has been necessary to prevent what otherwise would be a very limited use of aluminum, said Mr. Archer. As a result, the variety of cast-aluminum and wrought-aluminum products has been greatly extended in respect to both size and complexity of form. At the same time, the costs of the various fabricating operations have been substantially reduced. In general, it may be said that material in any form required by the automotive industry is now being, or can be, produced commercially. Sand castings weighing up to 3800 lb. have been made, and permanent-mold castings up to 57 lb. and die castings up to 12 lb. have been produced. Larger pieces can be made whenever the requirements arise. Forgings have been made which weigh from about ½ oz. up to 700 lb. Strong aluminum-alloy ingots weighing about 2100 lb. and comparable in size with ingots used in steel mills have been successfully rolled on an experimental basis. Aluminum is inherently very adaptable to fabricating processes and no fundamental reason has appeared which seems to limit the products that can be made.

Weight-Saving Considerations

Mr. Archer said further that it is not a new principle but is a somewhat neglected one that the possibility of saving weight in mechanical construction by the use of aluminum is often due to its great rigidity under transverse loading in relation to its weight. Many parts or structures are designed with larger sections than would be necessary for the required strength merely to attain the desired stiffness or resistance to deflection within the elastic limit. This is often true where gray-iron castings are used instead of a stronger material such as cast steel, or where plain carbon-steels not heat-treated are used instead of heat-treated alloy-steels.

The object of reducing the weight of parts in automobile construction is often more than a desire merely to reduce total weight, Mr. Archer remarked. In the case of reciprocating parts like pistons and connecting-rods, reduction of weight decreases bearing pressures and inertia whether the reciprocating masses are balanced or not, and if they are not perfectly balanced the reduction in weight also results in decreased vibration. The reduction of unsprung weight is regarded as more important than the reduction of weight above the springs, because of the attainment of improved riding-qualities. A special object of reducing weight is sometimes to improve the balance of the car as a whole as, for example, in the reduction of weight at the front end. A similar consideration is involved in the use of aluminum bodies to lower the center of gravity of the car. More than the reduction of gross weight is involved in the case of rotating masses, as in wheels where the kinetic energy of rotation is added to that of translation.

Even when the object of reducing the weight of parts is merely to reduce the total weight of the car, Mr. Archer continued, it is important to consider the cumulative effect of many small reductions. To use aluminum instead of iron or steel for any one part, such as a transmission case, saves only the difference between the weight of the aluminum part and the iron or steel part. If these savings are sufficiently numerous, however, the aggregate saving may well be such that further reductions become possible in the weight of other parts of the car such as the frame, the springs, and finally the engine. This cumulative effect becomes most apparent when an attempt is made to use aluminum to the greatest possible extent, as was done in some experimental cars built by the Aluminum Co. of America. The substitution of aluminum for cast iron and steel in these cars resulted in a saving of about 50 per cent; that is, 1 lb. of aluminum replaced 2 lb. of another material. The combination of acceleration and economy attainable in a car of this type cannot be duplicated in a car of similar size made of steel and cast iron.

In conclusion, Mr. Archer predicted that the use of aluminum in automotive vehicles of all kinds for the sake of improved performance is at the beginning of an upward trend, that increased use in commercial vehicles for the sake of economy is already under way, and that the urge of economy ultimately will extend its use to the passenger-car field.

The discussion following the paper centered largely on technical details, such as the strength of aluminum parts under tensile and torsional stresses, compared with the strength of similar parts made of other materials such as steel and cast iron.

Using the Street Plant

Miller McClintock Tells How City Traffic Congestion Is Relieved

CITY streets comprise a municipal plant that is utilized probably less efficiently than any other, yet it has been proved that it is possible to increase by 30 per cent the capacity of streets that are regarded as saturated with traffic. Conditions that result in this great plant inefficiency also prevent the potential efficiency of the motor-vehicle being utilized to anywhere near its possibilities. After pointing out these truths in the language of the engineer, Dr. Miller McClintock, director of the Albert Russel Erskine Bureau of Street Traffic Research, went on to tell members and guests of the Pennsylvania Section, at its April 17 meeting in Philadelphia, of some of the measures that have been put into effect in other cities with notable advantages.

Besides the members of the Pennsylvania Section, a dozen guests and several Metropolitan Section members were in attendance, among the guests being David Kirschbaum, chairman of the traffic committee of the Philadelphia Chamber of Commerce; William C. Haddock, of the traffic committee of the Philadelphia Chamber of Commerce; Elwood B. Chapman, president of the Chestnut Street Association; W. S. Canning, traffic engineer of the Keystone Automobile Club of Philadelphia; W. H. Metcalf, of the Philadelphia Automobile Trade Association; Capt. Robert Wassing, of the Philadelphia Police Department; and John C. Long, secretary of the traffic committee of the National Automobile Chamber of Commerce.

After opening the meeting with an announcement that the May 8 meeting of the Section is to be devoted to the subject of Aviation Engine Design, to be discussed by R. W. A. Brewer, Chairman N. G. Shidle introduced Dr. McClintock with some remarks explaining that the traffic topic was chosen for the April meeting as it was thought that it would be a good thing, both for the cities and the engineers, if more engineering were used in the solution of traffic problems, and that an intelligent solution is essential to the future progress of the vehicles that engineers are designing and building. He also referred to traffic studies that Dr. McClintock had made and methods of traffic regulation he had introduced in Los Angeles, Chicago, San Francisco, Boston and other cities.

"It is not at all improbable that you and I will be driving at an average rate of 65 m.p.h. within the next decade," asserted Dr. McClintock, referring to the present handicap of environment in cities that limits passenger-car speed to an average of 16

TYPICAL TRAFFIC CONDITIONS AT MARKET AND EIGHTH STREETS, PHILADELPHIA

m.p.h. and motor-truck speed to 8 to 10 m.p.h. Under present conditions in parts of some cities it probably is true that an increasing amount of trucking can be done more economically with horse-drawn vehicles. Each city has two principal methods that it can use to relieve traffic congestion and reduce accidents. One is by adopting a better plan or system of major traffic streets for communication between the central area and the outlying areas, and better construction of the highways themselves. The other is by better regulation of traffic.

Elevated Highways Needed

In the first part of his address, devoted to the first of these methods, the speaker referred to high-crowned roadways and short-radius turns built, and still being built, for horse-drawn vehicles, whereas the higher speed of motor-vehicles requires long-radius turns super-elevated on the outside. Without going into the subject of city planning to any extent, the speaker indicated that his prediction of the 65-m.p.h. speed was based on the expectation that cities will build elevated drives and other special automobile thoroughfares having no grade intersections. A number of these are already building or contemplated. Chicago is now definitely planning a loop of travel to carry traffic out in a northwesterly direction at any rate of speed that may be placed upon it. This will be elevated for a considerable distance. An outer driveway is now being developed along the entire lake front, connecting with Jackson Park on the south and Lincoln Park on the north. "Build elevated highways to serve as through feeders and collectors of traffic and eliminate cross-interference, and you will make it possible to utilize the full potentialities of the motor-car and, I believe, will make it a much more standard individual means of transportation than it can otherwise ever be," asserted Dr. McClintock.

Regulation Based on Studies

Twelve American cities now have city government bureaus employing traffic engineers whose work is to study traffic congestion and accidents and to develop regulation. The tendency is not to regulate traffic by guesswork, Dr. McClintock said. He then told of the success of the progressive signal system adopted in Chicago. This, he explained, is a system of controlling a series of lights to give the Go signal successively in a sequence of time, the time interval between two lights corresponding to the time required for a car to travel the distance between them, at a speed of, say, 15 m.p.h. Thus a driver can proceed the full length of the street at a uniform rate without any stop for cross traffic. On Wabash Avenue, where this system is in operation, a car can average 14½ m.p.h. while on Michigan Boulevard, where a 30-m.p.h. speed is permissible, the actual over-all speed is only 11 m.p.h. because of stops for the red signal.

Abolish the Parking Privilege

Street parking in congested areas is an evil that the speaker indicated can be abolished with advantage to merchants, car owners and the automotive industry. After a comprehensive study in the Chicago loop district, parking was prohibited and, instead of a decrease in store trade, it was found that all the larger department stores have shown an increase in sales this year over the corresponding period before the non-parking regulation was adopted. Moreover, whereas formerly an over-all speed of 9½ m.p.h. was very difficult, it is now possible to get through at a rate of 14½ m.p.h. Ample garage facilities exist for day storage of cars at 50 cents an hour, and the cars are cleaned and washed. This is a convenience and saving of irritation to the owners, and the dealers benefit. Instead of private automobiles being driven out of the loop, all transportation agencies have shown an increase. Passengers carried by common carriers increased 6.5 per cent; and by private automobile 9.3 per cent.

Peak Load Another Problem

Uneven distribution of the traffic load on the streets during the day is a problem that will have to be faced, asserted Dr. McClintock, who cited the morning and evening congestion and the "recreational" peaks after dinner. Some idea of the cost of these peaks to business concerns operating fleets was given by figures kept for six months in San Francisco by the Standard Oil Co., the Yellow Cab Co. and others. These estimated from their cost-account statements of accidents, repairs and liabilities, a saving at a rate of $2,000,000 a year as a result of the operation of a new traffic-control plan.

In Chicago, where the question of staggering trucking between the peak periods of other traffic was under study, a large fleet operator told Dr. McClintock that, if he could assume all the railroad terminal contracts, he could do all their hauling at two-thirds of the present contract prices, and pay his men time and overtime, by conducting the business at hours when the streets are not congested. "We shall have to face the necessity, in the very near future, of adjusting our old business habits so that we can not only stagger the time when the people go to work but segregate the hours when the traffic movements are carried on in the cities," declared the speaker in conclusion.

The address received hearty applause, and much discussion followed, participated in by Mr. Kirschbaum, Captain Wassing, Mr. Long, Dr. McClintock, Mr. Chapman, Mr. Canning, Dalton Risley, Jr., Mr. Metcalf, and the Chairman, Mr. Shidle.

Oil-Engine Research

DEVELOPMENT of the high-speed Diesel oil-engine for use in aircraft was the subject of a most interesting address given at a meeting of the Dayton Section on the evening of April 25 at the Dayton Engineers' Club following a members' dinner. The speaker was W. F. Joachim, chief of the powerplant laboratory of the National Advisory Committee for Aeronautics at Langley Field, Va., and a member of the committee on powerplants for aircraft, with headquarters in the City of Washington.

Mr. Joachim, who has been engaged in conducting some interesting research work with high-speed photography of fuel sprays in the cylinder-heads in his study of oil engines, showed and explained this method of research. He reviewed in detail the nozzle-development work of the Advisory Committee, outlined the advantages and disadvantages of the Diesel engine for automotive use, and described typical oil engines of the high-speed, high-capacity class.

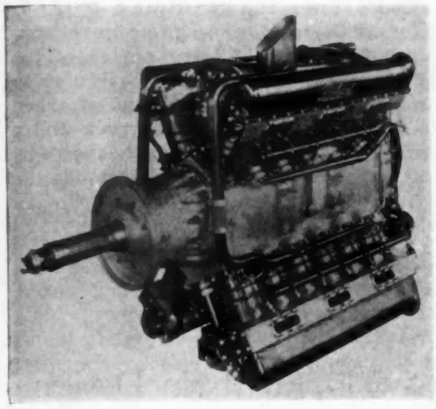
The committee's powerplant laboratory has been engaged in study of and experimentation with light-weight aircraft engines of the two-stroke-cycle air-cooled type and of superchargers for both water-cooled and air-cooled engines.

Following the presentation of Mr. Joachim's paper, the attending engineers, representing Diesel-engine builders, participated with the speaker in a lively discussion of the oil-engine subject.

Packard X Engine Described

MUCH larger and more powerful airplanes capable of enormously high speed will be produced within the next 10 years, in the opinion of L. M. Woolson, aeronautical and research engineer of the Packard Motor Car Co., who described the Model-X 24-cylinder Packard 1500-hp. aircraft engine, equipped with a supercharger, to nearly 300 members and guests of the New England Section at the meeting held in Boston on April 11. This was a joint meeting of the Section and of the Boston Section of the American Society of Mechanical Engineers, and was held at the service station of the Packard company on Commonwealth Avenue. Frank E. H. Johnson was chairman. Preceding the technical session, a buffet supper was served.

Numerous lantern-slide illustrations were used by Mr. Woolson for descriptive purposes. The supercharger is



THE PACKARD X 24-CYLINDER 1500-HP. WATER-COOLED AIRCRAFT ENGINE

mounted on the nose of the engine and is driven directly from the crankshaft. It is of fairly large size but is designed with a view to eliminating interference with the cowling of the engine, which is shown in the accompanying illustration and is of the water-cooled type.

Lantern-slide illustrations of various types of air-cooled aircraft engines were shown and commented upon by Prof. C. Fayette Taylor, of the Massachusetts Institute of Technology, who also compared the advantages and disadvantages of the water-cooled and air-cooled types of aircraft engine.

The merits of the centrifugal type of supercharger were stated by S. A. Moss, of the General Electric Co., in the discussion which followed the illustrated talks.

Great Body Enthusiasm

TREMENDOUS success attended the second meeting of the new Body Division of the Detroit Section in its attendance, entertainment, gustatory and technical features. As "Bill" Davis threatened they would do, the body men, on April 23, beat the Section's Aeronautic Division meeting held on April 17. Four hundred and ninety members and guests partook of the exceptionally good dinner served by the Book-Cadillac at 6:30 p.m., and another 100 filled the balcony when the meeting started at 8 p.m.

Better entertainment than at any previous meeting was arranged by Edge Austin. Besides excellent dance music and several specialty numbers, a dancing girl in Bowery costume performed a turn as a "body in the rough" that is reported to have "gone over big."

WORK SHEET OF THE GANG

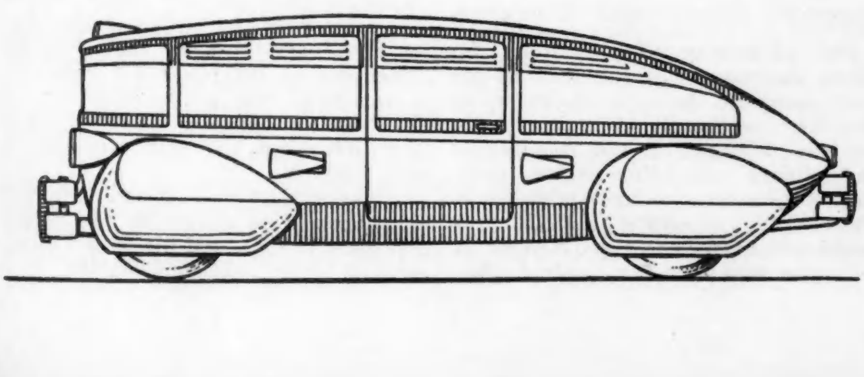
Each member present was supplied with a "work sheet" laid out by Mr. Davis, consisting of a number of sheets fastened together. These gave the job numbers and listed the operations as follows:

Job. No.	Operation
1	Division Assembly
2	First Set-Up (soup)
3	First Rough Stuff
4	Sub-Assembly (dinner)
5	Change in Design (entertainment)
6	Second Rough Stuff
7	Conference Starts
8	"Walt" Fishleigh Calls for Cheers
9	Carl Parsons Introduces "Daddy" Johnson
10	"Daddy" Johnson
11	Davis Introduces Hermann Brunn
12	Hermann A. Brunn

As in the case of the first Body Division meeting on March 19, every body plant in Detroit was represented at the April meeting but the groups were larger. Members of the Society were present from Amesbury, Mass.; Syracuse, N. Y.; Elizabeth, N. J.; Cleveland and Toledo, and Grand Rapids, Mich. Even a French firm was represented, Mr. Darien, of Hibbard & Darien, Paris, being present.

The speaker of the evening was Hermann A. Brunn, president of Brunn & Co., Buffalo, the "dean of American automobile body designers," who delivered an address on The Trend in Body Design.

Mr. Davis and his committee received congratulations on the successful results of their efforts in organizing the meeting, which was indicative that the Body Division meetings will be one of the big features of next season's Detroit Section program.



Papers on Chassis Lubrication

Southern California Section Discusses the Problem with Oil and Service Men

THE Los Angeles City Club was the rendezvous for 178 members and guests of the Southern California Section who met April 13 to hear papers on the subject of chassis lubrication. Of this number, 153 sat down to the members' dinner.

In opening the meeting, Chairman Ethelbert Favary called on Robert J. Pritchard, of *Western Flying*, who is a member of the committee making arrangements for the National Air Races to be held in Los Angeles next September. Mr. Pritchard announced that it had just been definitely decided that the meet will be held at Inglewood. Prizes to the amount of $125,000 will be offered for the races, including a non-stop race from New York City, a transcontinental race with 18 control stations, an international race from Canada, two races from points in California, and the usual program of races at the field.

BIG AIRPLANE ASSEMBLY EXPECTED

Admiral Reeves had assured the committee that the entire aircraft forces of the United States Navy will be in Los Angeles at that time, which is soon after a concentration of the Navy air forces in San Diego. More than 300 Navy airplanes, all of this year's make, will fly over the city in a succession of squadrons. In addition, there will be about 200 Army airplanes and about 1000 commercial airplanes at the races, it was said. The National Aeronautical Meeting of the Society will be held in Los Angeles at the time, and a great aeronautical tent-show is being planned in connection with the races.

Nominations for Section Officers for the coming year were brought in by Charles H. Paxton, chairman of the Nominating Committee, as follows: Chairman, Eustace B. Moore; Vice-Chairman, William H. Fairbanks; Treasurer, J. J. Canavan; Secretary, F. C. Patton; and additional members of the Governing Board, Eugene Power, Wendell E. Mason and Ethelbert Favary.

It was announced that the next meeting of the Section will be on May 11, and the subject will be Modern

Service Station and Garage Equipment for Reducing Cost of Operation, Maintenance and Repairs of Motor Vehicles.

Worm-Gear Lubrication

N. C. French, a lubrication engineer of the Union Oil Co., read the first paper of the evening concerning the lubrication of shackle bolts and worm gears. He said that the main requirements of a general chassis lubricant are that it shall act as a lubricant, as a dust seal and as a rust and rattle preventive.

Practically all greases are soaps in which a certain amount of oil has been incorporated, and the lubrication depends upon the oil; but in practical operation, Mr. French said, there are several reasons why it is not advisable to use oil alone. The ideal chassis lubricant should have the consistency of No. 1 or No. 2 cup grease and should be like soda-soap grease into which has been incorporated enough light steam-cylinder stock to give the consistency required.

In regard to worm-gear lubrication, Mr. French said that 70 per cent of the truck models of 1½-ton capacity and upward, and 80 to 85 per cent of all trucks of this capacity made, are equipped with worm drives. The worm being above the gear, the lubricant must have sufficient fluidity to be carried upward on the worm and splashed over the thrust bearings. Steam-cylinder stock of high flash-test and a viscosity of 170 to 200 Saybolt sec. at 210 deg. fahr. should be used, with no soap.

Mr. French reported that a force-feed pump has been placed on the market to circulate the oil in a worm-drive axle. He also referred to an improved design of worm drive that has been introduced by a large axle-manufacturer, having both thrust bearings at one end of the worm and a plain roller-bearing at the other end. This will make possible closer adjustment of the bearings. An improved form of worm-gear teeth giving a considerably larger contact area is used in the same design of axle.

Extols Periodic Lubricating

Chassis lubricating and tightening was extolled by D. R. McBryde, president of the McBryde Lubricating Service, who prophesied that there will be legislation within a few years compelling motorists to carry service cards just as now they must carry drivers' licenses.

Service offered by Mr. McBryde's organization includes systematic lubrication and tightening of stated parts after periods of 500, 1000 and 5000 miles of operation. Responsibility to users of this service for any damage from lack of lubrication is assumed by the organization, and the service is said to result in greatly reduced upkeep expense.

"One shot" lubrication, as applied to the Chandler car, was described in a short paper by E. V. Normoyle, who is connected with the Southern California distributors of this car. A paper was read also by Harold T. Ramsey, automotive engineer of the Standard Oil Co. of California.

Reading of the papers was followed by full discussion, one of the features of which was the description by J. V. Ainsworth, master mechanic in the employ of the City of Los Angeles, of the effectiveness of a pump oil-circulating and cooling device that he had attached to a rear axle. With it a truck and a trailer operated without excessive heating under conditions that had made the axle red-hot with only the ordinary provision for lubrication.

Pistons and Piston-Rings

Indiana Section Hears of Developments in Design and Methods of Gaging

FROM 250 to 300 members and guests of the Indiana Section listened with great interest to three papers on pistons and piston-rings at the April 12 monthly meeting in Indianapolis. Section Chairman George H. Freers presided, and Secretary R. P. Lewis read an invitation from Purdue University to hold the next meeting of the Section at West Lafayette. This was reinforced by a statement from Philip H. Pretz, who said that the student group and faculty are much interested in having the meeting there, and that there will be much of interest to be seen in the laboratories, as well as a baseball game and golf in the afternoon. Upon motion of William G. Wall, it was voted to accept this invitation. The meeting will be held May 5. Prof. A. E. Hershey, of the University of Illinois, will read a paper on Diesel engines at the technical session in the evening.

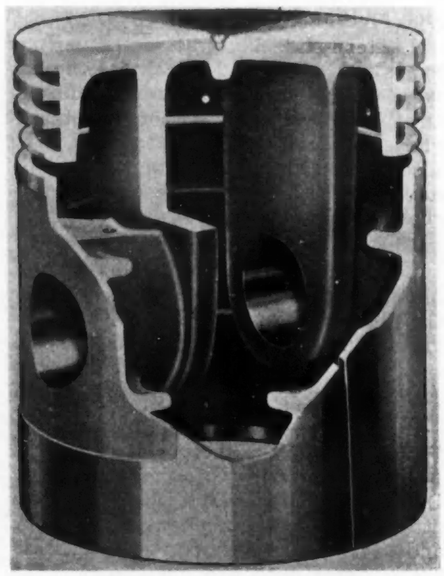
General Manager Clarkson reported that the Society is having a healthy growth and development under the presidency of Colonel Wall. He also recounted some of the attractions of the coming Summer Meeting in Quebec.

In the engineering profession, according to Mr. Clarkson, the volume of things we do not know is increasing rapidly. Formerly a man was supposed to be educated when he came out of college; now we have decided the more a man is educated the more he has to learn. We need more facts, more ideas, and more devices; and no agency can so well maintain certain activities in connection with getting these additional facts as can the Society.

Reducing Piston-Skirt Expansion

Full Aluminum-Alloy Pistons for Close Clearance was the title of the first paper of the evening, given by Ray Day, of the Ray Day Piston Co. An iron piston, of the size required by an ordinary automobile-engine, probably will have a clearance of 0.003 in. Theoretically, according to Mr. Ray, it would not fit at first, but it does fit well after running a few hundred miles, and continues to fit because its expansion is the same as that of the cylinder. Aluminum pistons do not work the same, because of the difference in expansion rate.

In spite of the various methods that



CUT-AWAY VIEW OF RAY DAY ALUMINUM-ALLOY PISTON

The Piston-Head Is Supported at About One-Third Its Diameter by Struts from the Inner Ends of the Piston-Pin Bosses

have been developed for controlling the skirt expansion, said Mr. Ray, the expansion of the head is transmitted to and distorts the skirt. In his own design of piston, the skirt is separated from the head, the only connection being from near the center of the head, at about one-third its radius, to the inner end of the piston-pin boss. As a result, if the piston-head expands 0.012 in. in diameter, the expansion that influences the skirt amounts to only 0.004 in.

Cross-sections and cut-away views of the piston were shown on the screen. The skirt is split, and fits with a clearance of only 0.002 to 0.003 in. It is

ribbed in a way that is reported by Mr. Ray to cause it to remain round as it expands, resulting in a full bearing surface on the cylinder, as shown by the wear marks.

PISTON-RINGS WITH AN OIL CUSHION

A novel departure in piston-ring construction was described by Harry M. Bramberry, engineer of the General Piston Ring Co., who gave credit to piston-ring makers for much improvement in the manufacture of conventional piston-rings, with the result that they give better performance. The rings specifically described by the speaker differ in construction from the usual ring and require a modified piston. They are the result of special development and research, some of which was done at the Bureau of Standards and the aeronautical engine laboratories of the Navy Department, and some at the laboratories of interested manufacturers of engines and motor-cars. The resulting Tungtite ring is said now to be standard equipment on all six-cylinder Chrysler cars.

These rings are applied in pairs to the upper end of a piston which is reduced in diameter more than ordinarily. Each ring has a flanged extension at one side so that its face is wider than the part which enters the groove. Each ring is in a separate groove, the distance between grooves being such that the flanges of the two rings in each pair come close to each other but with sufficient clearance to allow oil to collect between them.

A design shown included two pairs of the L-section rings in four grooves at the top of the piston, with a single oil-control ring of conventional grooved and slotted design below them. Rings of this flanged design are said to trap the oil and to cause a greater amount of heat transfer to the cylinder-walls because of their greater area of contact. With this construction it is said that an oil seal is maintained between the flanged ring and the three sides of its groove, this resulting in reduction of wear of the ring and the groove, and in greatly reduced gas leakage and oil consumption.

To get the full benefit of this construction, Mr. Bramberry says that an aluminum piston with an especially thick head should be used, the extra thickness extending down to carry the heat past the rings.

In the discussion that followed the reading of this paper Mr. Bramberry emphasized the importance of clearance between the flanges of the two piston-rings in one pair. Without this clearance the rings do not gather a seal of oil. Mr. Bramberry had several samples of pistons and rings with which he illustrated various points. He showed also a tool that is used in the Chrysler factory for opening the piston-rings to a predetermined diameter, thus avoiding distortion in assembling.

Measuring and Testing Piston-Rings was the title of a paper by Ralph R. Teetor, chief engineer of the Perfect Circle Co. The author described various conventional and special devices for gaging the characteristics of piston-rings. This portion of Mr. Teetor's paper will be found in the Production Engineering section of this issue of THE JOURNAL.

Mr. Teetor also reported some observations from curves based on dynamometer engine-tests in which data on oil consumption and gas leakage past the piston were obtained. He finds that oil consumption usually is least between 30 and 35 m.p.h., being increased at lower speed because of the greater vacuum and at higher speed from the results of the speed itself. Gas blow-by is found to increase very gradually at the lower speeds and much more rapidly at high speeds. The rate of leakage at high speed is less consistent than at low speed.

Research Work Featured

Jehle Describes Modern Laboratory—Aerodynamic Motion Pictures Are Exhibited

CHAIRMAN FISHLEIGH of the Detroit Section captured "Sid" Dresser of the Metropolitan Section and exhibited him at the meeting held April 2 in Detroit. He told Dresser that the 316 members and guests who attended the dinner and saw the show staged by Edge Austin, and the 460 then in attendance at the technical session, represented just a sample of what the Detroit Section can do.

Without casting any reflections on the Metropolitan Section, Fishleigh claimed that this meeting was simply a good average regular first-class Detroit product. He made this claim to Dresser, right out in front of all the people, and then claimed further that Dresser was thereby "dumbfounded." Whether the dumbfounded part of it be true or not is a matter of conjecture, but it did not prevent Mr. Dresser from giving the audience a racy account of the big Diesel-engine meeting held by the Metropolitan Section recently aboard the new motorship Saturnia in New York Harbor.

This talk was received by the assembled multitude with true wild-west acclaim, to which Mr. Dresser replied, in effect: Mr. Chairman and determined Detroit Section members, when a Metropolitan Section member comes to Detroit you certainly do give him that grand and glorious feeling. But I must remind you that we had 488 at the dinner aboard the Saturnia, which, by the way, was not a free dinner, and 635 attended the technical session and inspected the ship.

Further preliminaries at the technical session included talks by representative members of the Detroit Section on the subject of means for stimulating Section activities and increasing the membership. A paper was then presented by Ferdinand Jehle, of the White Motor Co., and this was followed by aerodynamic motion-pictures.

Mr. Jehle said in part that resourcefulness in research should, when possible, begin when the building or the laboratory room is designed. Provision must be made for floors to which machinery can be bolted; for cranes which can move the heaviest dynamometer; and for drains which can handle large quantities of water. Different kinds of electric current must be supplied at many convenient locations, and numerous conveniently located outlets for compressed air, gas and water. It is desirable also to provide easily accessible connections to lines of piping which connect with vacuum.

Features of the laboratory described by Mr. Jehle include rails set in the floor and spaced 4 ft. apart and water drains spaced every 20 ft. and terminating in two headers spaced 10 ft. apart which extend the entire length of the laboratory. A main switchboard is needed to control electric current for the laboratory and for the entire building. Electrical outlets con-

FERDINAND JEHLE

nected with the different kinds of current generated should be liberally provided. A transfer crane running on monorails should be installed so as to be available over the entire length of the laboratory, the roof structure being designed so that the monorails can be moved when necessary or additional ones easily installed. In this manner the entire floor area can be covered and all apparatus can be handled satisfactorily. The various pipes should run along the walls or on the columns, and their outlets for compressed air, gas, water and vacuum should be numerous. One feature of advantage is to use tees for all pipe joints instead of elbows or couplings and to close their unused openings with pipe plugs. Even though a large number of outlets have been provided, the use of tees makes it possible to tap into these lines at various places when occasion may arise, without disconnecting the permanent piping.

After describing the various types of instruments and testing equipment used in laboratory work, Mr. Jehle outlined some of the problems which are solved in a laboratory. These include the life-testing of different accessories, such as switches, ignition apparatus, impulse couplings, automobile horns, and the wear of flywheel ring-gear teeth. He gave also an outline of engine-test methods, and a description of automatic and semi-automatic means for recording fuel consumption and speed, as well as a detailed description of the timing instruments used.

Ultra-Speedy Research Photography

An interesting and unusual feature of the technical session was the showing of kinematographic studies in aerodynamics obtained by high-speed motion-picture methods employed at the Aeronautical Research Institute of the Tokyo Imperial University, Japan. This wonderful aerodynamic film, the photographs of which were taken at the rate of 20,000 per sec., was presented recently by Baron C. Shiba, distinguished Japanese scientist, to the School of Aeronautics of New York University. The procedure employed in producing the film was described recently by Alexander Klemin,[1] professor of aeronautical engineering, Daniel Guggenheim School for Aeronautics, New York University. Tokyo University for many years has been carrying on aeronautical research work of the highest value and its kinematographic studies are a remarkable contribution to science.

The film as presented by Baron Shiba includes: air flow around a R.A.F.-15 airfoil at 29-deg. incidence; a modified R.A.F.-15 airfoil with a Handley-Page slot at 29deg. incidence; a cylinder with air sucked away to smooth out the flow; a Baumann wing in which is found a peculiar double passage or slot at the rear; the Waldo wing with flaps; the tip of an airscrew under static conditions; the tips of two airscrews in tandem; an autogiro; and a vacuum bulb shattered by a bullet. The wind speed was generally 11 m. (36.09 ft.) per sec., with exposures at the rate of either 2100 or 3000 per sec. Only in the case of the shattered vacuum bulb was the rate of exposure raised to 20,000 per sec.

[1] See *Mechanical Engineering*, March, 1928, p. 217.

Distinctive Truck Features

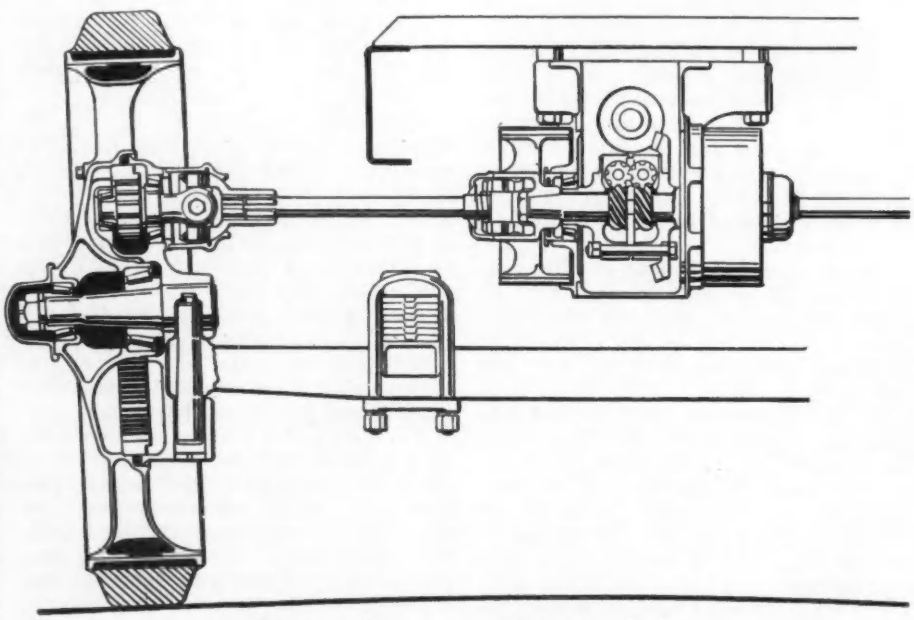
Engineers Tell Metropolitan Section of Peculiarities of Their Products

At the Building Trades Club, on April 18, 140 members of the Metropolitan Section sat down to dinner and 57 more arrived later, making the total attendance at the truck meeting almost 200. In opening the meeting, Chairman E. F. Lowe reminded the members that they were indebted to the Meetings Committee of the Section, under the chairmanship of T. C. Smith, for the excellence of the meeting programs that they have enjoyed. He also recommended early action in regard to reservations for the Summer Meeting and showed films of the City of Quebec. A special train will be run from New York to Quebec for the meeting.

As the motor-truck meeting was arranged by him, J. F. Winchester was called to preside during the presentation of the papers, and he proceeded directly to the business of introducing B. B. Bachman, past-president of the Society and chief engineer of the Autocar Co. Mr. Bachman brought greetings from the Pennsylvania Section, and mentioned the traffic meeting it held the night before which should be good for Philadelphia.

The use of bolts instead of rivets for the mounting of various brackets on a frame was the first peculiarity of Autocar trucks discussed by Mr. Bachman. This practice had been urged by the service department, but it was not adopted until the speaker was convinced of its importance by an experience during some road testing far from the factory or any place where repair facilities were available. An undermined road caused a broken spring-hanger, and, before the rivets were cut and a new spring-hanger applied, Mr. Bachman was persuaded that the use of bolts has many practical advantages.

Since that time it has been the practice of the Autocar Co. to bolt frame-brackets in place. A sizing drill is passed through the holes with the bracket in place to allow for a tight fit of the bolt. This practice avoids difficulty from poorly fitted rivets and, when looseness does develop, it can be corrected by tightening the bolt.



Walter Steering and Driving Axle
Differentials Are Made with Worm Gears. The Front Differential Is in the Transmission, the Rear in a Separate Case

Bushings in the brake linkage were also spoken of as a peculiarity of Autocar brakes. A bushing makes possible the use of an ideal bearing material, according to Mr. Bachman, and also provides for the easy renewal of wearing surfaces and the rejuvenation of the truck after it has developed a looseness in these parts.

Hydraulic Brakes and Passenger-Car Engines

Greetings from the Detroit Section were brought next by George P. Anderson, of Dodge Bros., who has spent a number of years in the various departments of the affiliated organization of Graham Bros.

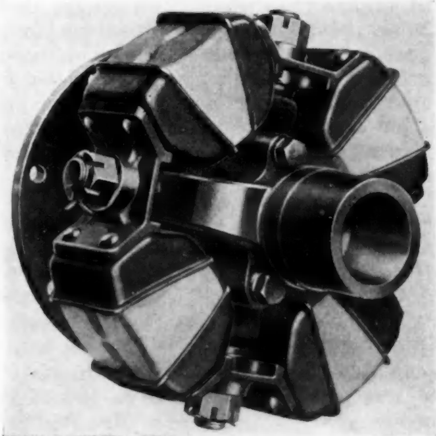
The most distinctive feature of the trucks he described was said to be the hydraulic four-wheel braking system, which relieves the chassis of a large number of rods, shafts, and levers and provides perfect equalization and brake action independent of spring deflection. The fluid used in this system is a mixture of castor-oil and alcohol, with an agent to neutralize the fatty-acid content of the castor-oil and avoid any resulting deterioration of the metal and rubber used in the system. This fluid is not affected by temperature within the required range, except by the expansion, which is automatically compensated for by the reservoir at the master cylinder. Supplementary to the hydraulic service-brake is a hand-brake applied to a drum at the rear of the transmission.

For reasons of economy, it is natural for a manufacturer of passenger-cars and motor-trucks to use the same engine in both if it is suitable. Substantial production economies result, and price is an important consideration in marketing a product.

The smaller sizes of Graham Bros. commercial chassis are powered with the Dodge Bros. four-cylinder engine. The 2-ton truck and the three models of motorcoach are powered with the Dodge Bros. Senior Six, the cylinder dimensions of which are 3⅜ x 4½ in.

This Truck Really Has a Suspension

Probably the most distinctive of the peculiarities reported in any of the papers of the evening is the rear axle of the Relay truck, described by W. J. Baumgartner, chief engineer of the Relay Motors Corporation. This is an internal-gear-drive axle having its drive pinions hanging directly below the wheel centers when the truck is standing idle. When power is applied the pinion is free to swing forward, and climbs up on an arc inside the internal gear, lifting the frame and load of the truck with it. When the pinion has reached a position determined by the tractive resistance, the wheel begins to turn, the position at any moment depending on the relation between the load and the tractive resistance. In extreme cases the driving axle can swing until it strikes a stop, and the resulting impact helps to start the truck. In addition, the reaction at the ground during the lifting of the load causes greatly increased traction.



Mack Rubber Torque-Insulator

Whenever power is applied the load begins to move forward before the road wheel begins to turn, and the start was said by Mr. Baumgartner to be easier and more gradual than with a rigid drive. In going over an obstruction, either forward or backward, the wheel is retarded while the load swings forward and upward, then the wheel follows more rapidly until it is again on a normal level, its center often getting ahead of the pinion center after passing over an obstruction. A diagram thrown on the screen indicated that the vertical acceleration of the load is appreciably less with the swinging drive-axle than with the conventional type.

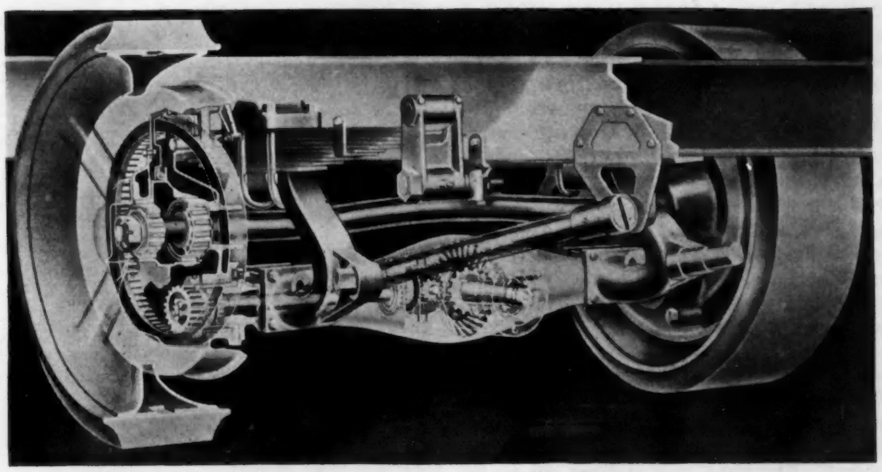
Mack trucks were represented by A. F. Masury, who listed the advantages of chain drive as follows: (*a*) high efficiency; (*b*) great reliability and ruggedness; (*c*) ease of changing ratios; (*d*) ease and economy of maintenance, because it is comprehensible to most truck operators; (*e*) flexibility; (*f*) light unsprung weight; (*g*) good ground-clearance and clearance for body or trailer mounting; and (*h*) availability of jackshaft for brakes.

Mr. Masury said that Mack trucks have used chain drives for 28 years, and that, after a time when most other truck makers had adopted enclosed drives, a number of them had returned to the chain. However, he did not claim the chain drive to be suitable for all conditions, and it is well known that many Mack trucks are built with dual-reduction drives.

The use of rubber in mounting units on the chassis was featured by Mr. Masury by means of motion pictures. A number of detail views showed applications for mounting the engine, transmission, radiator, springs, steering-gear and gasoline tank, and the whole was made more impressive by a view of a motorcoach chassis on which arrows appeared successively at 26 points where rubber shock-insulators are used. Two of the less familiar ones are a gasoline-tank three-point mounting, which eliminated an elusive noise, and a torque insulator which serves as an elastic universal-joint. The action of the more familiar rubber spring-mounting was well illustrated by a motion picture of the end of a flexing spring with its rubber block cross-lined and confined behind a transparent plate.

Novel Brake-Drum Mounting

Bringing greetings from the Cleveland Section, A. J. Scaife, of the White Motor Co., told of some of the peculiarities of White trucks. A noteworthy feature of the engine-lubricating system is a horizontal oil-screen over almost the whole area of the oil-pan, near the bottom. Oil is pumped from above this screen into the circulating



Phantom View of Relay Truck-Axle

Road Wheels and Brake Drums Are Attached to the Dead Axle. Chassis Springs Are Supported from the Live-Axle Housing, Which Is Free to Swing below the Dead Axle

system, which is provided with large drilled holes and steel tubes cast in place rather than with cored passages. Returning to the oil-pan, the oil is delivered below the screen. Before being recirculated it must pass over the screen, which is not likely to become clogged because of its large area and the fact that any impurities tend to settle away from it to the bottom of the oil-pan.

Mr. Scaife was asked about two-bearing crankshafts and said that the design of a crankshaft will vary according to the requirements. If a four-cylinder engine is being designed for the utmost ability in a small space, a two-bearing shaft can be made to give a very good account of itself. If high output is required and space is not closely limited, more bearings may be used to give maximum service.

He described a novel method of mounting brake-drums whereby a drum having a tapered hole is mounted on a splined shaft by means of a tapered collet that is drawn tightly into place like the tapered collet which is familiar to toolmakers. This construction is used for service brakes on the propeller-shaft, sometimes with a single drum and sometimes with a drum on each side of a tubular cross-member. The taper collet is held in position by three studs through the spokes of the drum.

Single-reduction axles with a standard gear-reduction of 7.13 to 1 are used on White 2½ and 3-ton trucks. With a four-speed transmission having a comparatively high range of ratios, the ability usually desired in first speed is obtained. For unusual requirements, an auxiliary transmission can be furnished.

Four-Wheel Drive Differentials

Maurice Walter, chief engineer of the Walter Motor Truck Co., the last speaker of the evening, said that four-wheel-drive trucks are the most logical and efficient equipment for hauling where there is no road, for transportation of tonnage with trailers or semi-trailers, and for snow removal.

One of the important questions of the four-wheel drive is that of differentials. If three ordinary differentials are used, the traction can fall to almost nothing when one wheel is on a slippery spot. The same is true with two differentials and two wheels on ice, and besides there is slippage in rounding a turn that may amount to as much as 20 per cent.

Differential locks and ratchet differentials have their objections, and Mr. Walter's solution is three differentials in which are used worm gears with lead angles selected to give a degree of reversibility that will deliver 80 to 90 per cent of the torque to one wheel if necessary. Such a differential depends for its success, he said, upon running at higher than rear-wheel speed, this being provided for by a 5-to-1 internal-gear drive at the wheel. Some of these machines are said to have developed a tractive effort of 7000 to 8000 lb. on snow and ice-covered roads where the treads of track-laying tractors would slip.

Five-speed transmissions with geometrically progressing ratios are used in these units, the low-gear ratio being 10 to 1. The standard reduction is 8.5 to 1 on high, giving a road speed of 25 m.p.h. in high gear and a tractive effort of about 14,000 lb. in low. In some cases a high-gear reduction of 10 to 1 is provided. This gives 100 to 1 in low gear, beyond which Mr. Walter has found no advantage.

The meeting was closed very interestingly with motion pictures depicting snow removal in Wisconsin. These were furnished by Mr. Masury, who averred that the motor-trucks shown were not Macks but Walters. A number of different combinations were seen in action, among them being two-wheel and four-wheel-drive trucks and track-laying tractors with V-type and rotary plows; and even four-wheel-drive trucks coupled together to buck deep drifts with a plow.

Students Hear D. P. Barnard

AUTOMOTIVE Fuels and Lubrication as the subject of an address by D. P. Barnard, 4th, before the S. A. E. Student Branch and the aeronautical engineering students at the Massachusetts Institute of Technology on April 6. The speaker attacked the problem of automobile-engine lubrication in particular, introducing the theory briefly and telling of the research for oils of the most suitable character for high-speed high-compression engines. His address was so interesting that it held his audience away over the time limit.

An Aviation Outing

WASHINGTON SECTION members to the number of 25 enjoyed a most interesting and informing monthly meeting on Wednesday, April 25, when they visited Hoover Field and eight had airplane flights over the City of Washington, and the whole party inspected the factory of the Berliner Aircraft Co. in Alexandria, Va.

Meeting at the Racquet Club at 4 p.m., the members rode in a motorcoach to Hoover Field, at the south end of Highway Bridge across the Potomac River. An air view of this field is shown in the accompanying engraving. During the ride, eight of the return cards sent in by members were drawn and the lucky members whose names were on the cards were given free flights in the airplanes of the Potomac Flying Service. The lucky members were B. F. Baker, J. A. Worthington, C. S. Bruce, C. S. Smart, H. K. King, A. W. Herrington, A. P. Petre, and H. Clausen.

From Hoover Field the party rode to the Berliner aircraft factory, where they saw airplanes under construction and Henry Berliner explained in detail the construction from the ground up, answering questions the asking of which was led by J. L. Endicott and C. O. Pooley.

On the return trip from the factory, the party stopped for dinner at the Little Tea House, where discussion of the observations was continued.

Hoover Field, Virginia, Opposite the City of Washington

Steering-Gears and Shimmy

F. F. Chandler Discusses Steering Problems and Milwaukeans Debate Front-End Phenomena

MEMBERS of the Milwaukee Section spent a delightful evening threshing over the moot questions of steering and car front-end phenomena at their regular monthly meeting, held April 4 at the Milwaukee Athletic Club, but adjourned before solving all the problems. Chairman Fred M. Young presided. The speaker of the evening, F. F. Chandler, vice-president and chief engineer of the Ross Gear & Tool Co., gave an illustrated address on steering problems and the design of steering-gears. Before and after the meeting the members examined an exhibit of different types of steering-gear brought for the occasion by Mr. Chandler.

On convening the meeting, Chairman Young announced that subsequent to the address by Major Williard F. Rockwell at the February meeting of the Section, on the subject of Military Motor Transport, the Governing Board of the Section had prepared a resolution for adoption. Secretary Arthur C. Wollensak then read the following resolution, which was put to vote and approved:

"That the Milwaukee Section believes that the automotive industry and the Army will benefit greatly if appropriations are increased for the purpose of providing modern and uptodate heavy transport equipment to replace equipment which has been in service more than 10 years, and to which no additions have been made since the war."

Duesenberg the May Attraction

Fred S. Duesenberg has been secured as the particular luminary to shed his radiance as the speaker at the next monthly meeting of the Section, on May 2. Those who have heard him talk would not miss doing so again for a world-series game, regardless of his subject; and when he talks to a gathering of automotive engineers about supercharging, two-cycle engines, high compression and high engine-speed they are sure to forget the time to adjourn to the Simmons and the Ostermoor.

Mr. Chandler, in his address, reviewed the automobile developments that have brought upon the engineering fraternity the steering problems of the last few years, one of which that is not commonly mentioned being the greater amount of driving by women, who cannot exert the strength of a man in turning the steering-wheel. To reduce the amount of effort required, steering-gear reduction ratios have been increased; but, as these increases required more than the 1½ turns from hard-over to hard-over position to which the public is accustomed, the cam-and-lever type of steering-gear was designed having a worm of variable ratio to render steering easy without excessive turning of the steering-wheel.

F. F. Chandler

The real reasons for the development of such a variable ratio were primarily to accommodate the public and to produce a mechanism that would take care of the increased load imposed by balloon tires, heavier vehicles and higher speeds. Reduction of the helix angle, with consequent increase of over-all ratio, was necessary, particularly in mid-position driving; but, to avoid too many turns of the wheel, the reduction ratio is decreased at both ends of the range in the Ross type of steering-gear. In some other types the exact reverse of this arrangement is embodied.

It is doubtful, said Mr. Chandler, if people generally realize the great amount of thought and effort that lies behind a simple thing like a steering-gear; and he showed a number of lantern slides of instruments his company designed for the purpose of getting chart records of drag-link stresses and the amount of effort expended by the driver in steering. Several charts were also shown that gave the records of actual road driving-conditions.

There is no perfect steering-gear and never will be one, asserted Mr. Chandler. They are and should be in the process of development all the time, because conditions are constantly changing. Referring to transmission of road shock through the steering-wheel, he said that the effect can never be eliminated or the problem solved unless the car manufacturers design a front end so that the forces will not be produced or the steering-gear manufacturer either designs his steering-gear so well or so poorly that the shock will not be felt. The finest steering of an automobile can be secured only when the driver can sense the road unconsciously through the steering-wheel in his hands. The steering-gear must be just sensitive enough to road conditions so that the driver has the "feel" of the road without getting the disagreeable greater reactions.

One factor of the problem is the kind of surfaces in contact in the steering-gear, and the other is the contact angle of the surfaces. The helix angle of the gear must be great enough so that the steering mechanism just approaches the condition of reversibility. No automotive engineer, in the opinion of the speaker, should select the steering-gear to go into the car that he designs, because he is not designing his car to be handled by an expert like himself but to be handled by the non-expert public.

Shimmy Tackled Manfully

Stating that he hesitated to touch on the difficulties presented by road shock, shimmy and tramp, Mr. Chandler courageously took the plunge and opened up a subject to which virtually all of the subsequent discussion was devoted. If the angle of inclination of the steering-knuckle king-pin is kept down to a small minimum, he said, road shock will not enter into the problem much. If actual center-point steering is adopted, however, the difficulty will be increased at slow speed, because the tire tread in contact with the road must be twisted around the center point.

Low-speed shimmy, he asserted, can virtually be wiped off the map, because it is a consequence of looseness of steering parts, which can be remedied by servicing. But high-speed shimmy, which usually is accompanied by axle tramp, presents a very complicated problem, involving gyroscopic effect on the front wheels. Actual pressures set up in the steering mechanism by these phenomena are beyond comprehension. Inside pressures on the contact surfaces frequently approach 1 to 1½ tons in normal operation, and when to these are added the terrific reactions that come during high-speed shimmy, the strongest man cannot hold the steering-wheel.

So far as the manifestation of shimmy is concerned, each car is an individual problem. Steering difficulties seem to be increasing all the time,

largely because the public is becoming more and more critical and wanting to go to higher speeds. At best the front end of a motor-vehicle is a most unstable assemblage of mechanical parts, and the makers of shock-absorbers, snubbers and stabilizers have a great part to play.

DISCUSSERS WANT TO KNOW

Keen on the trail of the axle tramp and shimmy bogey, the discussers plied Mr. Chandler with many questions. Putting in rubber cushions and the like to damp the reaction, said J. C. Slonneger, "has only changed the trouble from the kitchen to the dining-room; it is not out of the house." Mr. Chandler remarked that an experimental car of a prominent make in which the springs were rubber mounted could not be kept on the road at all, but some of the best-steering cars he knows of today are rubber mounted. In response to a question by Henry L. Debbink, he said that, in general, he does not think front-end shackling of the front springs results in great improvement, although on a certain car having this construction, putting in the spring-bolt so that it has some longitudinal movement when the spring is flexed improved the car action greatly. The presence or absence of springs in tie-rods and drag-links seems to make little if any difference in the operation, he replied to an inquiry from Secretary Wollensak. If springs are used, they must be heavy enough to hold the two front wheels in nearly correct relationship, and when they do this the steering mechanism is so nearly solid that reactions are final.

PRICE FACTOR BLOCKS DEVELOPMENT

Hydraulic pressure in steering will transmit the effort of the driver to the front axle, without the intervention of a drag-link, in a way that should kill the reaction, Mr. Chandler answered to a question by Mr. Slonneger, but the use of hydraulic steering is probably far off on account of cost. This reminded him to say that the greatest trouble with steering-gears is introduced by the purchasing agent; better steering-gears would be on the market if the purchasing agent were willing to pay the price for them.

Speaking of tramping and shimmying, Mr. Chandler said, "It is an illuminating and educating experience to ride the front bumper and watch what is going on at the front end of the car, provided you can stay on." He has done this many times and found it rather terrifying. Despite the new and probably continuing difficulties, Mr. Chandler predicted that, with certain improvements of which he knows and that are likely to come, the steering will be further improved as car speeds increase and the public demands more comfortable riding.

COMPUTATIONS OF LITTLE AVAIL

Asked by A. L. Zimmerman if he did not design his steering gears with a factor of safety based on computations as to the maximum stress and line-contact pressure between the comparatively small cam and the worm, Mr. Chandler said that the pressures are virtually infinite and he did not think that computations were worth the paper on which they are written; the only satisfactory results in steering-gear designs come from experience. The enormous pressure on a steering-gear at the line or the point of contact does not seem to create any bad effects or result in breakdowns unless there is faulty material, workmanship or lack of proper lubrication.

M. F. Moore, of the Nash Motor Co., corroborated a statement by Mr. Chandler that shimmy is always preceded by tramp, and told of making a study of front-end phenomena by means of slow motion-pictures which showed that motion began with a slight tramp which gradually built up to a point where gyroscopic action began and shimmy started. As to building cars with king-pins vertical or at different inclinations, he was of the opinion that either the inclined or the vertical type can be worked out to a satisfactory solution. The inclined pin is not so sensitive to caster angle as the former.

Although it is possible to eliminate some of the bad reactions by introducing friction in the steering mechanism, this produces hard steering, said Mr. Chandler. Similarly, extra leaves in the front spring change the periodicity and almost without exception have improved the steering action but have impaired the riding-quality.

On the question of the relative advantages of the variable reduction-ratio giving easy steering at the mid-section and that giving easy steering at the ends of the range, which point was raised by H. L. Bemis, Mr. Chandler said that more steering-wheel movement in center driving position means easier steering in the mid-position and relieves road shock. At the hard-over position, which is used frequently, the driver has enough physical reserve to accomplish the quicker wheel-turn.

Decimal Point Misplaced

IN the news report of the February meeting of the Southern California Section the decimal point in three figures on p. 386 of the March issue was one place too far to the left. The measurement of expansion of a 17-in. brake-drum due to heating, as stated by Dr. F. C. Stanley, should read:

"Accurate measurements on a Cadillac 17-in. drum at 500 deg. fahr. showed 0.056-in. expansion. An expansion of 0.056 in. is just enough to take up all the clearance of 0.025 in. between the drum and the lining which was at that time given in the brakes."

Personal Notes of the Members

Young Appointed Chief Engineer

O. W. Young, who has been assistant manager of the western division of the Hyatt Roller Bearing Co., making his headquarters at Chicago, is now located at the general offices and factory of that company in Harrison, N. J. He assumed his new duties as chief engineer of the company on March 1.

Mr. Young has been with the Hyatt company in various capacities since 1915. Prior to that time he was employed successively by the Western Electric Co., the Chicago Engineering Co., the Economy Motor Car Co., the Minneapolis Motor Co., the H. E. Wilcox Motor Co. and the McVicker Engineering Co.

Since his election to membership in 1917, Mr. Young has participated actively in the work of the Society. He has served several times on the Agricultural Power Equipment Division of the Standards Committee, has been a member of the Finance Committee and of the Meetings Committee, and in 1922 was Second Vice-President representing tractor engineering. Upon becoming a Member of the Society, Mr. Young joined the Minneapolis Section, but later transferred his membership to the Mid-West Section, now known as the Chicago Section. He was chairman of the Chicago Section in 1926.

Budd Wheel Secures Begg

R. S. Begg has resigned his position as chief engineer of the Jordan Motor Car Co., which he held for 11 years, to become associated with the Budd Wheel Co. as chief engineer. Prior to his affiliation with the Jordan company, Mr. Begg was successively employed in various capacities, largely in connection with experimental work, by the Packard Motor Car Co., the Chalmers Motor Car Co., the Hudson Motor Car Co., the E. R. Thomas Motor Car Co., the Sheldon Axle Co. and the Thos. B. Jeffery Co.

A Member of the Society since 1914 and of the Cleveland Section since 1917, Mr. Begg has taken a prominent part in Society affairs. In 1918 he was treasurer of the Cleveland Section. For the last six years he has been a member of the Standards Committee, serving actively on the Axle and Wheels Division, the Springs Division, the Tire and Rim Division and the Passenger Car Division. He was chairman of the last-named for three successive years. At various times he has been a member of the Highways Committee, the Special Committee on Standardization Policy, and the Advisory Committee on Automobile Locks. In 1924 he was appointed representative of the Society on the executive board of the American Automobile Association, and he is this year serving in the same capacity.

R. K. Jack Located in Lansing

R. K. Jack has opened an engineering office in Lansing and will engage in special automotive development and research.

After receiving his technical education and early automotive experience in Scotland, his native country, Mr. Jack came to this Country in 1911 to act as designer with the American Locomotive Co. Subsequently he accepted a position as assistant engineer with the Cadillac Motor Car Co., from which he resigned in 1915 to become chief engineer of the Russell Motor Car Co. in Canada. Two years later he severed his connection to become works manager for Arrol-Johnston, Ltd., of Scotland, but returned to America in 1919, when he became affiliated with the Olds Motor Works in the capacity of chief engineer. He returned to Scotland again in 1927 as a consulting engineer, and has now established his present office in Lansing.

A Member of the Society since 1915 and of the Detroit Section for several years, Mr. Jack has been active in the standardization work of the Society, having served on the Transmission Division for three consecutive years. He presented at the 1927 Annual Meeting a paper entitled The Constantinesco Torque-Converter. This was published in the October, 1924, issue of THE JOURNAL.

Keith Joins J. I. Case Co.

R. R. Keith, recently in charge of all automotive transportation engineering for the International Harvester Co., has accepted a position with the J. I. Case Threshing Machine Co., as manager of the South Works, including the tractor works, the foundry and pattern shop.

Important positions held by Mr. Keith prior to his connection with the International Harvester Co. include 5 years with Fairbanks, Morse & Co. as assistant superintendent in charge of shops at the Three Rivers Works; 1 year with the Holt Co. as works manager of the Peoria Works; 2 years with the Moline Plow Co. as works manager of the tractor works and 3½ years with the International Harvester Co. as superintendent of its tractor works at Chicago.

Elected to membership in the Society in 1922, Mr. Keith has served on the Engine Division, the Truck Division and the Production Division of the Standards Committee, and in 1926 he was a member of the Meetings Committee. Since 1925 Mr. Keith has been an active member of the Chicago Section.

Norton with Counties Motor Co.

W. W. Norton, formerly vice-president and production manager of the Autocar Co., has become general manager of the Counties Motor Co., distributor of General Motors trucks in the three counties adjoining Philadelphia. Mr. Norton first became affiliated with the Autocar Co. in 1902 as foreman of the experimental and production departments, was re-employed in 1907 as general superintendent and was appointed vice-president in 1913. In February of this year he was reelected to the Board of Directors. Previous to his connection with the Autocar Co. he was employed by various manufacturing concerns, as tool designer and factory executive.

A member of the Production Advisory Committee and for many years a Pennsylvania Section member, Mr. Norton has been actively interested in Society affairs since his election to membership in 1913.

Martin Commands Army Train

K. G. Martin, who holds the position of account manager with the Frank Presbrey Co., will be in command of the First Army Train, a unit of the National Reserve Officers Corps, when it goes on active duty, July 1, for 14 days' field training in motor-transport problems at Fort Hancock, Sandy Hook, N. J. This Train is a completely motorized organization, constituting the transportation elements designated to serve the First Army troops and function with the Transportation Services of the corps and divisions making up the Army.

Mr. Martin, with previous military school and National Guard experience, was commissioned as a captain in the motor transport section of the Quartermaster Corps of the United States Army in 1917, was promoted to Major in June, 1918, in France, and received the rank of Lieutenant Colonel in 1919, when he was appointed chief motor-transport officer of Base Section 1, American Expeditionary Force in France. A very interesting account of the activities of the Base Section, Motor Transport Corps, was written by

(Continued on p. 34)

March Council Meeting

A SESSION of the Council was held in New York City on March 28, those attending being President Wall, Past-President Hunt, First Vice-President Strickland, and Councilors Templin and Veal.

A financial statement as of Feb. 29, 1928, was submitted. This showed a net balance of assets over liabilities of $203,229.55, this being $13,171.18 more than the corresponding figure on the same day of 1927. The gross income of the Society for the first 5 months of the fiscal year amounted to $154,232.65, the operating expense being $157,424.62. The income for the month of February was $31,515.79. The operating expense during the month was $32,689.79.

The election of 105 members, 8 grade transfers, 4 reinstatements, 4 reapprovals, and 4 resignations, on which the Council had acted by mail vote, were confirmed. One hundred and six additional elections to membership were approved, as well as 16 transfers in grade of membership. The resignations of 5 members were accepted, and 3 reinstatements to membership were approved. One application was reapproved.

David Ayr was appointed as the Society representative on the Sectional Committee on Small Tools and Machine-Tool Elements. Glenn L. Martin was appointed as the Society representative on the Sectional Committee on Aeronautic Safety-Code.

The following subjects were assigned to Divisions as indicated:

Lighting Division—Direction Lamps
Non-Ferrous Metals Division—Non-Ferrous Forgings
Production Division—Sand-Paper Tests
Production Division—Plain Cylindrical and Threaded Plug-Gages, and Ring Gages.

The appointment of F. H. Prescott as the Society representative on the Federal Specifications Board Committee on Storage-Batteries for Starting and Lighting and Radio was confirmed.

The Council considered a recommendation made by the Finance Committee against the incurring of expense of printing in separate form all papers presented at Section meetings for the purpose of distributing copies to all members of the Society in Section territory. The Council approved this recommendation of the Finance Committee. The matter had come up as a result of a resolution passed by the Sections Committee recommending to the Council that as soon as practicable all members be billed in one lump sum to cover National dues and Section dues, it being understood that all members in various Sections would be supplied with copies of the papers given at Section meetings. It appeared that the additional expense for printing Section papers would be at least double the amount of additional Section dues that would be collected.

John G. Utz

A LONG career of active and valuable service to the automotive industry and to the Society was brought to a premature close with the passing of John G. Utz last month in Detroit following a somewhat protracted illness. A host of men formerly associated with him in various motor-car and parts companies, and old and new friends who have served as officers and members of the committees of the Society, sincerely mourn their loss of a most helpful co-worker.

Young as the motor-vehicle industry is, the number of men who have been continuously engaged in it from its earliest inception in this Country is very limited, and it is with keenest regret that the extinguishing of the bright light of any of its pioneers who have shown the path to a multitude of followers is recorded. Mr. Utz was elected a Life Member of the Society by the Council 10 years ago in recognition of his service as Chairman of the Standards Committee in 1917. In 1916 and 1917 he was also a Councilor. During 1914 and 1915 he was Chairman of the Miscellaneous Division of the Standards Committee. In 1914 he was a member of the Meetings Committee, and in 1919 served as a member of the Membership Committee. The following year he was First Vice-President.

From 1913 to 1921 Mr. Utz was a member of the Cleveland Section, and upon removing to Detroit in the latter year, he transferred his membership to the Detroit Section, with which he was thenceforth affiliated.

Born at Marshalltown, Iowa, in 1880, Mr. Utz acquired his preparatory education at the Chicago Manual Training School and his technical education at Cornell University, which graduated him in 1902 with the degree of mechanical engineer. His connection with the industry, however, antedated his university years, as he was connected with the Cleveland Machine Screw Co., engaged in electric-vehicle work, from 1896 to 1898. From 1902 to 1913 he was connected successively with the Cleveland Automobile Co., the Berg Automobile Co., the Kirk Mfg. Co., the Olds Motor Works, the Autocar Co., the Thomas Detroit Motor Co., and the Abbott Motor Car Co. As consulting engineer he served the Perfection Spring Co. from 1913 to 1915, and in 1917 was chief engineer of the Standard Parts Co.

Mr Utz served his Country during the war, in 1918, as supervisor of engineering in the military truck production section of the Office of the Quartermaster General at Washington. At the conclusion of the war he returned to Cleveland, where he remained 2 years more with the Standard Parts Co. as engineering supervisor.

Moving to Detroit in 1921, he set up in business for himself as consulting engineer, making a specialty of automobile suspensions and leaf springs, and pursued his occupation as independent consulting engineer and expert patent witness continuously until this year.

Papers contributed by Mr. Utz to the Society include one on Cantilever Springs, published in THE TRANSACTIONS, 1915, Part 1; one entitled The Story of the United States Standard Truck, published in THE JOURNAL, April, 1919, and in THE TRANSACTIONS, 1919 Part 1; and one on The Engineer's Place in the Industry, published in THE JOURNAL, May, 1921.

Following an illness extending over 3 months, Mr. Utz died at the Battle Creek, Mich., Sanitarium, on April 14, and funeral services were held at the Hamilton Chapel, in Detroit, on the 17th. He is survived by his wife, his mother and a sister. He was a prominent Mason and a member of the Detroit Athletic Club.

Alexander W. Copland

AN inventor and manufacturer of note has been lost to the automotive industry, and a valued member and worker on its Standards Committee has been lost to the Society, with the crossing of the great divide by Alexander W. Copland, of Detroit. On the eve of probable wide recognition of the importance of his last contribution as an inventor, it is deeply deplored by his associates and many friends that Mr. Copland could not have been spared at least a few more years to see the fulfilment of his expectation. He had made many important contributions, especially of late to the gear-making industry, as an inventor and manufacturer, and the last of these, a new method of making relatively quiet in-

terchangeable gears in quantity production, is regarded by those who knew him well as his most important invention.

Only a few days before the sudden fatal termination of an illness extending through the last year, Mr. Copland had completed the outline of the subject matter that he wished to have included in the paper on A New Method of Cutting Gears to be presented at the transmission session of the Summer Meeting by Charles B. Logue and R. B. Fehr, both of the Copland Gear Lapping Syndicate, of Detroit, of which Mr. Copland was president. His health had improved so much in recent months that, accompanied by Mr. Fehr, he attended the convention of the American Gear Manufacturers Association in Rochester during the week of April 16. Consequently, his sudden passing at his home in Birmingham, Mich., on April 23 came as a severe shock to his friends and associates.

Elected a Member of the Society in 1912, when he was president and general manager of the Detroit Gear & Machine Co., Mr. Copland rendered valuable service as Chairman of the Transmission Division of the Standards Committee from 1917 to 1923. In 1925 he was a member of the House Committee. Besides holding membership in the Society, he was a member of the Detroit Club, the Detroit Country Club, the Bloomfield Hills Golf Club and the Bloomfield Open Hunt.

Mr. Copland was a native Detroiter, born in that city in November, 1867, and attended the public schools there and the Shattuck Military Academy.

For 20 years, from 1890 to 1910, he was actively engaged in the cracker and biscuit-baking industry, first as half owner and shop manager of the Detroit Cracker Co., in 1890 and 1891; next for a year in the business and manufacturing departments of the W. S. Baking Co., of Detroit; from 1892 to 1900 as manager of the Cincinnati branch of the National Biscuit Co.; and then for 2 years as manager of the Copland Bros. Bakery, at Somerville, Mass. For a number of years thereafter he was engaged chiefly in the inventing and manufacturing of automatic biscuit-making machinery. The years 1903 to 1905 were spent in London, England, assisting George H. Baker in a series of tests on the efficiency of the Baker patented transmission for Joseph Baker & Sons, Ltd. In 1909 Mr. Copland engaged in business for himself in his home city as proprietor of the Alexander W. Copland Co., making automobile parts. In 1910 he became president of the Detroit Gear & Machine Co., devoting his genius and energy to designing transmissions.

During the World War Mr. Copland rendered invaluable service on the truck standardization committee of the Society and of the War Department. A paper presented before the Society by Mr. Copland, under the title Transmissions for the Class-B Truck, was published in THE JOURNAL for January, 1918, and in THE TRANSACTIONS for 1918, Part 1.

Retiring from the presidency of the Detroit Gear & Machine Co. in 1926, he organized the Copland Gear-Lapping Syndicate, of Detroit.

It was while touring in Europe a year ago that Mr. Copland was taken ill. He is survived by his widow, two daughters, four sisters and a brother.

Al Copland was one of the best loved men in the automotive industry. His sincerity, ability and generosity were greatly admired.

Frank S. Lockhart

A BRAVE spirit, a lovable man and a progressive and highly competent designer is lost in the passing of Frank S. Lockhart. A Junior member of the Society, he proudly styled himself racing-car driver, and he was that par excellence. Barely 25 years of age, he had endeared himself greatly to his associates and many friends. He had been engaged in his vocation of race driving since 1922, beginning in California, where he built racing cars. He participated in all National events and won the Indianapolis Speedway 500-Mile Race in 1926. Latterly he was a member of the engineering department of the Stutz Motor-Car Co., devoting his attention to design work on the speed car, in piloting which he met his untimely and greatly deplored fate while racing down the beach at Daytona, Fla., at a speed of more than 200 m.p.h. Several weeks ago he had a miraculous escape from death when making a similar attempt to break the straightaway speed record.

Orlando J. Root

THE death of Orlando J. Root, vice-president of the Standard Calorimeter Co., of East Moline, Ill., on Feb. 16 is reported to the Society by Mrs. Orlando J. Root.

Mr. Root, who had been a member of the Society for the last 10 years, with the grade of Member, was widely known in the automotive industry, particularly in connection with his association with W. H. Van Dervoort since 1897.

Born at West Bay City, Mich. in September, 1868, Mr. Root was graduated from the mechanical engineering department of the Michigan Agricultural College in 1889 and for the next 5 years was assistant superintendent of the Lansing Iron & Engine Works, with the duties of designer and supervisor. From 1894 to 1897 Mr. Root was connected in a similar capacity with the Watertown Steam Engine Co., and in the latter year he and Mr. Van Dervoort organized the Root & Van Dervoort Engineering Co. and the Moline Automobile Co., of which organizations Mr. Root was secretary and treasurer from 1897 to 1908. He retired from active work from 1908 to 1917, but in 1917 resumed active work with the Root & Van Dervoort Engineering Co. in the capacity of vice-president. During more than 25 years Mr. Root was also part owner of the Standard Calorimeter Co. and was actively associated with it when he died.

Besides holding membership in the Society of Automotive Engineers, Mr. Root was a member of the American Society of Mechanical Engineers.

THE MONTCALM MEMORIAL AT QUEBEC

Applicants for Membership

The applications for membership received between March 15 and April 16, 1928, are listed below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ALEXANDER, H. RICHARD, draftsman, Lycoming Mfg. Co., *Williamsport, Pa.*

ALLEN, OLIVER FIELD, manager of automotive sales, International General Electric Co., Inc., *Schenectady, N. Y.*

ALLYN, HAROLD M., general supervisor of motor vehicles, Ohio Bell Telephone Co., *Cleveland.*

BALCHEN, BERNT, test pilot, Atlantic Aircraft Corporation, *Hasbrouck Heights, N. J.*

BAXTER, HOWARD, president, Howard Baxter, 2350 Webster Street, *Oakland, Cal.*

BEVAN, WILLIAM A., assistant professor of mechanical enginering in charge of aeronautics, Purdue University, *Lafayette, Ind.*

BLAKELEY G. B., New York representative, White Co., *New York City.*

BROWN, GILNOR H., service engineer, Republic Motor Truck Co., *Alma, Mich.*

BROWN, PERCY A., supervisor of inspection, Graham-Paige Motor Corporation, *Detroit.*

BURLEIGH, RAY T., assistant zone service manager, Chevrolet Motor Co., *Baltimore.*

CARVER, GROVER C., supervisor of rail motor cars, Boston & Maine Railroad, *Boston.*

CLEMENS, JOHN W., chief engineer, Patriot Mfg. Co., *Havelock, Neb.*

CONNAL, W. F., mechanical engineer, Canadian National Railways, *Montreal, Que., Canada.*

CONNELLYS, JAMES MAURICE, metallurgist and chemist, Electric Refrigeration Corporation, *Detroit.*

DAHL, JORGEN H., mechanical engineer, Norwegian State Motor Car Control, *Hamar, Norway.*

DANIEL, NORMAN HOYLES, service engineer, General Motors of Canada, Ltd., *Oshawa, Ont., Canada.*

DIEDERICH, JOHN W., staff engineer, Indian Motocycle Co., *Springfield, Mass.*

DISHMAN, S. R., JR., superintendent of plant, Associated Oil Co., *Honolulu, T. H.*

DOUGALL, HECTOR FRASER, Dougall Motor Car Co., *Fort William and Port Arthur, Canada.*

ELLIOTT, COURTNEY G., service manager, Sonoma Motor Sales Co., *Los Angeles.*

ERTL, ANTON GLORE, tester in experimental laboratory, Graham Bros. Truck Co., *Detroit.*

FARNSWORTH, WAYNE HEATHCOTE, testing and experimental engineer, Hall-Scott Motor Car Co., *Berkeley, Cal.*

FAROUX, CHARLES, editor *La Vie Automobile, Paris, France.*

FENN, ALAN REGINALD, managing director's assistant, Humber, Ltd., *Coventry, England.*

FERGUESON, A. P., body engineer, Graham-Paige Motor Corporation, *Detroit.*

FLYNN, JAMES W., inspection layout, checker and template maker, Edward G. Budd Mfg. Co., *Philadelphia.*

FOOTE, ORLO A., JR., purchasing agent and assistant secretary, Venango Mfg. Co., *Franklin, Pa.*

FOYST, J. G., assistant supervisor of time study, Chrysler Corporation, *Newcastle, Ind.*

FREERS, SIDNEY L., layout draftsman, Willys-Overland Co., *Toledo.*

FREUD, ARTHUR, sales representative, Mathews Mfg. Co., *Worcester, Mass.*

GIBIAN, EMIL, chief engineer, Vichek Tool Co., *Cleveland.*

GODLOVE, CHARLES, manager, Federal Motor Truck Co. of New York, Inc., *New York City.*

GRANT, RUDOLPH R., president and chief engineer, Dayton Airplane Engine Co., *Dayton, Ohio.*

GREEN, LEE BRITTON, developing engineer, Borden Co., *Warren, Ohio.*

GREGER, EDWARD J., inspector in testing laboratory, A. C. Spark Plug Co., *Flint, Mich.*

GRIFFIN, NICHOLAS M., vice-president, Mack-International Motor Truck Corporation, *Chicago.*

GROEHN, OTTO J., superintendent, Gratiot body plant, Hudson Motor Car Co., *Detroit.*

HALL, PERCY EDGAR, chief engineer, Bendix-Perrot Brakes, Ltd., *Birmingham, England.*

HAMMOND, CHESTER ARTHUR, service engineer, New Departure Mfg. Co., *Detroit.*

HANDLER, EUGENE, vice-president, treasurer and general manager, Lyons Storage Battery Co., *Belleville, N. J.*

HILL, JOHN B., sales engineer, New Departure Mfg. Co., *Detroit.*

HODGE, ERNEST W., superintendent of paint department, Hudson Motor Car Co., *Detroit.*

JURZEK, LEON J., factory manager, lamp plant, Ford Motor Co., *Dearborn, Mich.*

KING, HAROLD A., manager manufacturer sales, Seiberling Rubber Co., *Akron, Ohio.*

KLINE, JOHN H., local sales manager, International Harvester Co. of America, *Long Island City, N. Y.*

KNUTH, WILLIAM C., owner, Knuth Co., *Milwaukee.*

KREUTZER, JOSEPH, president and general manager, Joseph Kreutzer, Inc., *Los Angeles.*

LANE, H. S., sales manager, Garford Motor Truck Co., Inc., *Philadelphia.*

LUTZ, FRED F., superintendent of buildings and supplies, Bell Telephone Co. of Pennsylvania, *Harrisburg, Pa.*

MACKELLAR, IAN ALEXANDER, draftsman to plant engineer, John Deere Tractor Co., *Waterloo, Iowa.* L

MARQUIS, A. N., secretary and general manager, A. N. Marquis Co., *Oklahoma City, Okla.*

MCCANDLESS, M. LOWRIE, JR., specification engineer, Chandler-Cleveland Motors Corporation, *Cleveland.* L

MCCLELLAN, STEPHEN A., sales engineer in charge of commercial sales, Pratt & Whitney Aircraft Co., *Hartford, Conn.*

MCFADDEN, THOMAS JAMES W., district manager, Celoran Co., *Bridgeport, Pa.*

MCFARLAND, FOREST REES, draftsman, Packard Motor Car Co., *Detroit.*

MEEHAN, EDWIN J., experimental and research work, Divco Detroit Corporation, *Detroit.*

MILLER, HERMAN H., supervisor of time study, Chrysler Corporation, *Newcastle, Ind.*

MOSTHAF, EDWIN FREDERICK, engineer in charge of chassis design, Wright-Fisher Engineering Co., and Wright Flexible Axle Motors, Ltd., *Montreal, Que., Canada.*

NESBITT, JUSTUS P., student in industrial mechanical engineering, Pratt Institute, *Brooklyn, N. Y.*

OWEN, GEORGE E., sales engineer, L. C. Smith Bearings Co., *Chicago.*

PENNSYLVANIA PETROLEUM CO., INC., *North Kansas City, Mo.*

REID, W. T., president, Reid Aircraft Co., Ltd., *Montreal, Que., Canada.*

ROBSON, CLARENCE E., chief equipment engineer, Edward G. Budd Mfg. Co., *Philadelphia.*

ROUX, ROBERT, Walter Motor Truck Co., *Long Island City, N. Y.*

ROWLEY, MILLARD C., engineer, Lycoming Mfg. Co., *Williamsport, Pa.*

SAXON, DAVID L., vice-president, Saxon Stamping Co., *Toledo.*

SCHAUB, WILLIAM FULTON, manager, New London Coach Co., *New London, Conn.*

SCHLESMAN, CARLETON H., supervisor of motor division, general laboratories, Standard Oil Co. of New York, *Brooklyn, N. Y.*

SINITZIN, NICHOLAS N., aeronautical engineer, Sikorsky Mfg. Corporation, *College Point, N. Y.*

SLACK, CHARLES, in charge of automotive maintenance, Richfield Oil Co., *Huntington Beach, Cal.*

SMITH, PAUL A., mechanical engineer, Barber-Greene Co., *Aurora, Ill.*

STAMM, A. F., draftsman and designer on fire apparatus, International Motor Co., *Allentown, Pa.*

STONEBURNER, HARVEY J., designer, aircraft division, Ford Motor Co., *Dearborn, Mich.*

SWITZER, RALPH E., layout draftsman, Cadillac Motor Car Co., *Detroit.*

TEGNER, HENRY STUART, chief of technical sales department, Anglo-American Oil Co., Ltd., *London, S. W. 1, England.*

TURTON, THOMAS FREEMANTLE, works manager, W. G. DuCros, Ltd., *London W. 3, England.*

VAN BURDEN, NICHOLAS, tester and engine troubles, Town Taxi Co., *Boston.*

VAN HOVE, D. H., spring engineer, L. A. Young Spring & Wire Corporation, *Detroit.*

WATTERS, JOHN, JR., sales department, American Car & Foundry Motors Co., *Detroit.*

WESTER, ARTHUR A., president and general manager, Cork-Sealed Piston Ring Corporation, *Denver.*

WHITE, WILLIAM D., supervisor of production, Perfect Circle Co., *Hagerstown, Ind.*

Applicants Qualified

The following applicants have qualified for admission to the Society between March 10 and April 10, 1928. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member.

ALEXANDER, DON M. (A) first vice-president in charge of engineering and production, Alexander Industries, Inc., Alexander Industries Building, *Denver*.

ALLEN, RUSSELL E. (M) superintendent, Fay & Bowen Engine Co., Lake Street, *Geneva, N. Y.*

ARMOUR & CO. (Aff) Union Stock Yards, *Chicago;* Faulkner, Fred L., manager of automotive department.

AUSTIN, K. B. E., SIR HERBERT (M) chairman of directors, Longbridge Works, Austin Motor Co., Ltd., Northfield, *Birmingham, England*.

BARKER, GEORGE (A) service representative, General Motors Truck Co., 211 West 61st Street, *New York City*.

BATTLES, WALTER E. (J.) assistant manager of motorcoach body production, International Motor Co., *Allentown, Pa.;* (mail) 847 South Poplar Street.

BAUER, RICHARD (F M) chief works engineer, Deutsche Edelstahl Werke, *Bochum, Germany;* (mail) Arndtstrasse 5.

BEELAT, WILLIAM C. (A) assistant supervisor of patterns, Continental Motors Corporation, *Detroit;* (mail) 12338 Stoepel Street.

BENDER, CHARLES J. (A) president and treasurer, Ahlberg Bearing Co., 317 East 29th Street, *Chicago*.

BERRY, E. W. (A) mechanical superintendent, Benguet Consolidated Mining Co., P. O. Box 10, *Bguio, P. I.*

BERRY, WALLACE STOTT (J) engineer in automotive service department, servicing gasoline and gas, electric rail cars, J. G. Brill Co., Philadelphia; (mail) 260 Harvey Street, *Germantown, Philadelphia*.

BILLIOQUE, HENRY (M) chief engineer, Musa-Hartzell-Ducasse, Inc., 25 West 43rd Street, *New York City*.

BOYSEN, WILLIAM R. (A) sales engineer, Hyatt Roller Bearing Co., 10-142 General Motors Building, *Detroit*.

BURKE, WILLIAM H. (A) superintendent, Kermath Mfg. Co., *Detroit;* (mail) 5201 25th Street.

BUYSSE, RICHARD L. (J) engineer of motor equipment division, Michigan Bell Telephone Co., *Detroit;* (mail) 580 Seyburn Avenue.

CHANDLER, C. DEF. (M) editor Ronald Aeronautic Library New York City; (mail) 1424 K Street Northwest *City of Washington*.

DAVIDSON WARD F. (M) director of research Brooklyn Edison Co. Inc. 55 Johnson Street, *Brooklyn, N. Y.*

DINSON JOSEPH A. (A) master mechanic and acting works engineer, National Carbon Co. *Long Island City N. Y.;* (mail) 204 Theodore Street.

DROGITCH, M. G. (J) draftsman, Croll Reynold's Engineering Corporation, New York City, (mail) 633 South 18th Street, *Newark, N. J.*

EASTON, ERNEST E. (J) assistant chief engineer, Brown-Lipe Gear Co., *Syracuse, N. Y.;* (mail) 2925 South Salina Street.

EGER, KARL A. (M) assistant engineer, Leece-Neville Co., 5363 Hamilton Avenue, *Cleveland*.

FISH, EARL R. (M) chief engineer, Brown-Lipe Gear Co., 1117 West Fayette Street, *Syracuse, N. Y.*

GASTON, GEORGE L. (A) lubricating engineer, Standard Oil Co. of Indiana, *St. Louis;* (mail) 5942 Maple Avenue.

GAZDA, ANTON C. (F M) owner manager, Anton Gazda Fahrzeug-Stabil-Flugmotorenbau, 10 Arsenal, *Vienna, Austria*.

HAUCKE, OSWIN (M) manager of transportation equipment maintenance, Reid Ice Cream Corporation, 524 Waverly Avenue, *Brooklyn, N. Y.*

HOGE, WILLIAM L. (M) president, Mengel Body Co., Louisville, Ky, and vice-president, Mengel Co., 12th and Dumesnil Streets, *Louisville, Ky.;* (mail) Mengel Co.

HOLDEN, E. W. (F M) managing director, Holden's Motor Body Builders, Ltd., Adelaide, South Australia; (mail) Kalymna, Dequetteville Terrace, *Kent Town, South Australia*.

HOLLENBERG, STEWART G. (J) service manager, Northern Valley Sales, Inc., Englewood, N. J.; (mail) 36 Erie Street, *Dumont, N. J.*

HOWELL, N. D. (M) sales engineer, New Departure Mfg. Co., Bristol, Conn.; (mail) 3044 West Grand Boulevard, *Detroit*.

KAMRATH, HERBERT G. (M) experimental engineer, A. C. Spark Plug Co., *Flint, Mich.;* (mail) 2416 Detroit Street.

LEGROS, LEROY F. (J) chassis draftsman layout and design, American Car & Foundry Motors Co., *Detroit;* (mail) 59 Collingwood Avenue.

LEVY, JAMES (M) assistant body engineer, Hupp Motor Car Corporation, *Detroit;* (mail) 5586 Pacific Avenue.

LOCKHART, FRANK S. (J) racing car driver, Stutz Motor Car. Co., 1002 North Capitol Avenue, *Indianapolis*.

LYNCH, R. E. (J) assistant special equipment engineer, Graham Bros. Truck Co., *Detroit;* (mail) 2650 Northwestern Avenue.

MARTIN, JOSEPH A. (M) draftsman, Divco Detroit Corporation, *Detroit;* (mail) 2475 Richton Avenue.

MCCOOK, ARTHUR A. (A) supervisor of motor vehicles, Manhattan division, New York Telephone Co., 140 West Street, *New York City*.

MILLER, JOHN M. (M) president Miller Corporation, New Brunswick Airport, *New Brunswick, N. J.*

MULLIGAN, L. A (M) chief engineer, Joseph N. Smith & Co., Detroit; (mail) P. O. Box 277, *Dearborn, Mich.*

MURPHY, D. HAYES (A) president and treasurer, Wiremold Co., 410 Asylum Street, *Hartford, Conn.*

NEVIN, EDWARD (A) president, Nevin Truck & Bus Mfg. Co., 159 Remsen Street, *Brooklyn, N. Y.*

NORRIS, CHARLES B. (M) mechanical engineer, Haskelite Mfg. Corporation, Chicago; (mail) 245 Paris Avenue, *Grand Rapids, Mich.*

NYGARD, ERIC (A) instructor in civil engineering, Union College, *Schnectady, N. Y.*

OPIE, ERNEST J. (M) chief engineer and superintendent of engineering and production, Ramsey Chain Co., Inc., 1031 Broadway, *Albany, N. Y.*

PAXTON, GEORGE B. (J) test engineer, Harrisburg Light & Power Co., *Harrisburg, Pa.;* (mail) 1040 South 17th Street.

RAABE, ARTHUR E. (A) sales department, Eclipse Machine Co., 545 North Arlington Avenue, *East Orange, N. J.*

ROACH, J. D. (A) sales engineer, Hyatt Roller Bearing Co., *Detroit;* (mail) 13116 Kentucky Avenue.

ROEDER, DALE (M) designing, layout and testing, Ford Motor Co., *Dearborn, Mich.;* (mail) 20 East Tenny Street.

ROWE, ALFRED HARRY (A) supervisor of specifications, Continental Motors Corp., 12801 Jefferson Avenue, East, *Detroit*.

SAUER, LOUIS B. (A) manager of ignition department, Kellogg Switchboard & Supply Co., Chicago; (mail) 4220 Garden Avenue, *Western Springs, Ill.*

SCHITTKE, ROBERT (M) draftsman and designer, Olds Motor Works, *Lansing, Mich.;* (mail) 410 South Pine Street.

SCHMIDT, CARL (F M) managing director, Aktiebolaget Pentaverken, *Skoefde, Sweden*.

SCOTT, JAMES Y. (J) assistant to president and general manager, Van Norman Machine Tool Co., 160 Wilbrahan Avenue, *Springfield, Mass.*

SILLCOX, LEWIS K. (M) assistant to president, East Works, New York Air Brake Co., *Watertown, N. Y.;* (mail) 519 Washington Street.

SMITH CHARLES C. (M) development engineer on steel backed babbitt lined bearings, Cleveland Graphite Bronze Co., 880 East 72nd Street, *Cleveland*.

STOUP, GEORGE H. (A) president and general manager, Reo Birmingham Motor Co., 2015 Avenue C, *Birmingham, Ala.*

THIRKELL, GEORGE L. (F M) managing director Australian Metal Equipment Co., Proprietary, Ltd., 108 Jeffcott Street, *West Melbourne, Victoria, Australia*.

TITUS, RALPH H. (A) president and treasurer, Ralph H. Titus, Inc., 462 Main Street, *New Rochelle, N. Y.*

TURNER, MYRON W. (A) salesman, Electric Storage Battery Co., 8051 West Chicago Boulevard, *Detroit*.

TURNQUIST, EDWARD (M) assistant superintendent, plant 3, Delco-Remy Co., *Anderson, Ind.;* (mail) 131 West Sixth Street.

WALDRON, H. E. (M) draftsman and checker, Dearborn plant, Lincoln division, Ford Motor Co., Dearborn, Mich.; (mail) 1631 Lawrence Avenue, *Detroit*.

WALLACE-PITT, CYRIL ALBERT (A) Toronto representative of truck division, Durant Motors of Canada, Leaside, Ont., Canada; (mail) 47 Rusholme Park Crescent, *Toronto 3, Ont., Canada*.

WEISS, ADRIAN E. (M) secretary, treasurer and engineer, Superior Die Casting Co., 875 East 70th Street, *Cleveland*.

WALKER, JAMES J. (F M) service manager, General Motors Export Co., New York City (mail) General Motors of Japan, Ltd., *Kobe, Japan*.

WINKLER, LOUIS G. (M) chief mechanical engineer, Parts Corporation, 735 Virginia Avenue. *Indianapolis*.

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Notes and Reviews

These items, which are prepared by the Research Department, give brief descriptions of technical books and articles on automotive subjects. As a general rule, no attempt is made to give an exhaustive review the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B, Body; C, Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H, Miscellaneous; I, Motorboat; J, Motorcoach; K, Motor-Truck; L, Passenger Car; M, Tractor. *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3, Miscellaneous; 4, Operation; 5, Production; 6, Sales.

AIRCRAFT

The Problem of Noise in Civil Aircraft and the Possibilities of Its Elimination. By. W. S. Tucker. Published in *The Journal of the Royal Aeronautical Society*, March, 1928, p. 185. [A-1]

When the complete history of the present period is written, it should surely be described as the age of noise, and the airplane is no minor offender. This is the author's premise, which he supports by microphone records of the noise made by an airplane in flight and by enumerating, as the sources of the auditory disturbances that assault the passengers in a cabin, the airplane structure, the exhaust, the propeller, and the variegated medley of impulsive sounds.

An analysis is made of sounds generated and of possible protective devices against them, such as treating the cabin with sound-absorbent materials, silencing the engine, insulating the cabin, or introducing a ventilating system that does not give sound free access to the interior of the cabin. The improvements in the amenities of air travel that will be achieved by such expedients will, in the opinion of the author, amply compensate for the additional load and the increased running costs entailed.

Stress Analysis of Commercial Aircraft. By Alexander Klemin and George F. Titterton. Published in *Aviation*, March 12, p. 632; March 19, p. 704; March 26, p. 774; and April 2, 1928, p. 838. [A-1]

Aerodynamically efficient, structurally weak. This, the verdict on commercial airplanes given in these articles, is said to be based on the first year's experience with Government certification of the structural strength of commercial airplanes. The reason assigned by the authors is that the subject of the structural strength of aircraft, never having been put into a form in which it was available and understandable by those interested in the design and construction of airplanes, has never received the study it merited.

Aiming to fill this lack, the authors have written a series of 20 articles giving the fundamentals of elementary stress-analysis as applied to the design of airplanes. The articles are intended to help engineers to comply with the Department of Commerce stress-analysis regulations.

Of the instalments that have already appeared, the first two review the principles of mechanics that are applicable to the structure of the airplane under various loadings. The third instalment is concerned with the Department of Commerce requirements, and the fourth deals with the materials of construction.

Airplane Tires and Inner Tubes. By Charles J. Cleary. Published in *Aviation*, March 19, 1928, p. 702. [A-1]

Why and through what steps have airplane tires and tubes progressed to their present stage of development? Since 1920 the clincher-type tire has lost favor almost entirely, to be replaced by the straight-side type, for reasons given in this article. In discussing the structural specifications for casings, the author draws a contrast between automobile and aircraft requirements, and traces the causes behind the selection of the present rim sizes. Oversizing and the method of obtaining the proper angle of stability in oversizing are the topics finally considered in the section on casings.

Special design considerations arising from the use of drop-center rims are the chief points dealt with in connection with tube design. Finally, considering the tire as a whole, the relations between the tire contact-diagram, its load per square inch, the supporting load and the inflation pressure of the tire are worked out.

Oleo Gears for Aircraft. By Edwin E. Aldrin. Published in *Transactions of the American Society of Mechanical Engineers, Aeronautics Division*, January-April, 1928. [A-1]

After describing the various oil-damping devices for reducing the landing shocks of airplanes, the author presents a theory and test data for the design of the "oleo" type of landing gear. This type depends, for the shock-absorbing effect, on the flow of oil through an orifice. Tests with several forms of orifice, using different fluids under a steam hammer, gave satisfactory orifice coefficients for design purposes. Then, landing gears were dropped under weights with different combinations of orifice and needle, wheel, and tire through heights varying up to 42 in., and their performance was studied in slow-motion pictures and in cards from pressure indicators attached to the gears. It has been found that, in the plain oleo mechanism, together with tire and wheel, and with no tapering needle in the oil orifice, almost constant deceleration is obtained. Viscosity of the oil medium has little effect.

The Development of Large Commercial Rigid Airships. By Karl Arnstein. Published in *Transactions of the American Society of Mechanical Engineers, Aeronautics Division*, January-April, 1928. [A-1]

In this paper the author discusses airship safety, which he believes to be very high because of the multiplicity of means for obtaining the same end. He analyzed the various loads that are imposed on an airship; and well-based recommendations are made for methods of structural analysis and for load factors. The author studies the variation in weight with volume of various structural elements, on the basis partly of past experience and partly of careful investigation of many projects, and finds that the specific dead-weight decreases for airships up to 15,000,000-cu. ft. capacity, but only slightly beyond this size. From the point of view of transportational efficiency, the improvement with larger sizes continues almost indefinitely, at any rate well beyond a capacity of 15,000,000 cu. ft., which is the largest volume contemplated at present. The author's final conclusion is that it is possible to construct airships of any size that may be required to meet transportation problems, and that economy will improve from every point of view with larger sizes.

The Reid Reaction Apparatus. Published in *Flight*, Feb. 9, 1928, p. 80. [A-3]

Briefly, the Reid reaction apparatus

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